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PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF

PHILADELPHIA

VOLUME XXVIII

EDITED BY THE PUBLICATION COMMITTEE

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PROCEEDINGS

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PAPER NO. 1093.

THE BUILDING OF THE CITY.

HENRY LEFFMANN.
(Active Member.)

Read November 5, 1910.

THE figures of the United States census have shown for several decades a strong trend toward congestion of population in cities. It is true that the recent development of electric traction has slightly checked this movement, but it still remains a dominant influence. Space and time do not permit me to consider the several causes of this tendency, but it may be said, as a summary statement, that these are partly economic—that is, connected with industrial problems—and partly sentimental—that is, dependent on the gregarious disposition of mankind.

The origins of the human races are as yet unknown to us, but it is probable that some races are of very high antiquity, and that all were primarily of a very low order of mental and moral qualities. Some glimpses that ethnologic research has given us show man living in rude shelters, each family alone and at war with all others, subsisting by chase or on wild fruits, and being essentially in the same state as the most savage races today. Conditions slowly improved with some races, not appreciably with others. We are not able to determine the reasons for this difference. Probably the "aspects of

nature" had something to do with it. Among the first steps to civilization is fixation of abode. The nomad does not civilize. The Bedouin Arab is today almost what he was in the morning twilight of Oriental civilization. A powerful influence in this fixation of abode was the status of woman. Compelled by the very conditions of her life to remain at home while the men were out on the chase or making war upon enemies, she developed the arts of peace. It was her feeble attempts to till the ground and raise grain that led to the substitution of agricultural for pastoral life; it was her weaving and spinning that led to the substitution of textiles for skins as garments, and there is hardly any doubt that the first rude pottery was fashioned by her hands.

As the arts of peace grew, the arts of war declined, and mankind, finding strength and protection in numbers, established itself in communities, gave up some impulses and opportunities to obtain personal comfort and greater opportunities along other lines, and thus the city arose. There are many who deplore the tendency of the cities to increase; there are some who labor to counteract it and the cry "back to the land" has been much heard and little heeded in the last two decades.

Whether the rush to cities is favorable or unfavorable to the highest civilization need not be here discussed; the tendency is with us, and it behooves the practical man to endeavor to minimize the evil and enhance the good features.

It is proposed to lay before the Club some thoughts that have been in the writer's mind for a number of years, mainly tending to the view that cities ought to be built according to rule and measure. The modern city is merely a great house, and should be planned as a house is planned, though, of course, the labor of such planning is very great. Cities are no longer strategic points in great areas of unprotected lands. The modern states are in reality no longer dependent on

> "Cities high, with towers and turrets crowned,"

but the cities are the headquarters of the business and communal life. The progress of sanitary chemistry and engineering practice has been such that we are now capable of dealing satisfactorily with all the problems of transportation, illumination, police and fire protection, water-supply, sewage and garbage disposal, and communication of intelligence that arise in large cities.

A most important point in dealing with these several problems is to

anticipate them; not to wait until they arise and then have to deal with them under conditions that are antiquated and insufficient. Items appearing frequently now-a-days in the newspapers and journals show that many are thinking along these lines. The present contribution will be probably more radical than any yet offered. Experiments have often been made in building villages, but usually either as pure land speculations, or as a sort of benevolent feudalism in connection with some industrial enterprise. Pullman, Gary, the several villages that the Krupp company has built, and some small enterprises in connection with factories in England are instances. These operations, well called by socialistic writers "toy villages," are too narrow in scope and too much involved in the industrial accessories to exemplify the principle presented in this paper. The founders of the toy villages play at building and management for awhile, then grow tired or die and *laisser faire* methods prevail.

The successful city will be planned from the beginning, not only as to its construction, but as to its operation. It will be run as a corporation for reasonable profit, for it will be found that the most satisfactory service can be given to the residents in that way, and hence a steady increase of population will result. The details of construction will be worked out by engineers, and the details of business methods by financiers before the construction begins.

To make the paper less abstract, some of the features of the proposed "Twentieth Century City" will be set forth. Let it be called Protopolis—"The Model City."

Commercial opportunities must be given prominent consideration. It is evident that the industrial situation in civilized countries has now reached such development that commerce is one of the mainstays of national prosperity. For commerce, the city must be located on the shore of a large river or bay, affording a deep channel and ample anchoring ground. A considerable area of flat land, a few feet above high water, should be available. This should be mainland, or at most separated from the mainland by a narrow, shallow channel, navigable only for small craft. It will be an advantage if, at a distance of about 25 or 30 miles, the level of the land rises rather sharply to a height of several hundred feet, but this is not essential. The body of water on which the city fronts should be so wide that no appreciable influence can be exercised by a settlement on the opposite side.

Protopolis will be laid out in "unit areas," each say 5000 feet

square. A group of 25 such areas arranged as a square will constitute the "primary plan." Of course, just as William Penn laid out only two miles of the large area that was at his disposal, so the builders of Protopolis should control a much greater territory than that required for the primary plan; but the later operations will be merely repetitions of this plan.

Two sets of streets will be laid out. One set will cross at right angles, the other diagonally. This combination is seen in Washington, D. C., but it will be applied in the model city more extensively. Four serious defects have been noted in Penn's plan for Philadelphia: Lack of diagonal thoroughfares, narrowness of the streets, failure to reserve open spaces and areas for public buildings, failure to plan for

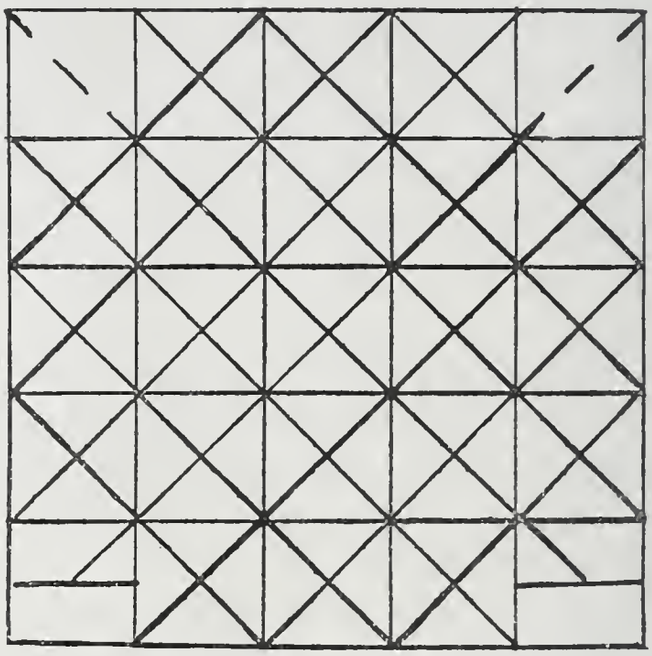


Fig. 1.

great expansion along the lines of the primary plan. In the model city the streets crossing at right angles will be of the uniform width of 100 feet from house to house, and the diagonal streets will be 200 feet. In the latter class the roadway will be of larger relative width than in the 100 feet streets. No traffic street will be less than 100 feet wide, but there will many non-traffic streets for special purposes, as will be set forth later. At each end of the water-front of the city one-half a unit area (2500 by 5000) will be reserved for park purposes, and at the line furthest from the water-front two unit areas will be reserved for the same purposes. Each unit will also have its own small park.

Fig. 1 shows the scheme of the primary plan of 25-unit areas.

Each side is 25,000 feet long. To avoid complication in the drawing, only a few of the streets crossing at right angles are shown, but all the diagonal ones are indicated. The larger park areas are shown by the suppression of all the streets, except one diagonal, which is continued through each park, of course, as a sunken way, as is done in the case of the traffic streets in Central Park, N. Y. In the center of

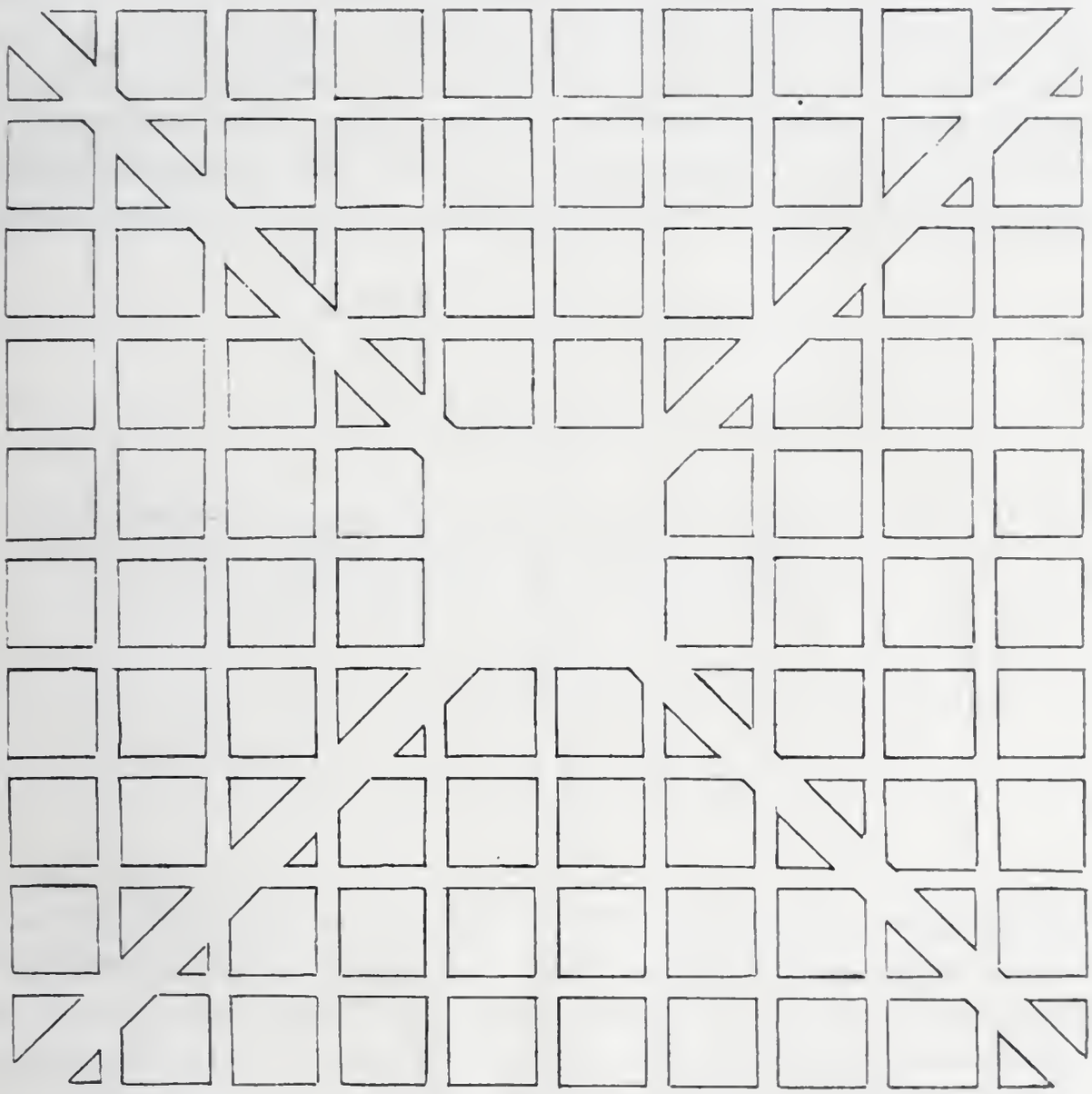


Fig. 2.

each unit area—the point at which two diagonals cross—four blocks are suppressed, making a local park area. All building blocks are 400 feet on each side. When occupied by ordinary residences, these blocks will be crossed in two directions, at right angles, by streets 50 feet wide not open to general traffic. These intersecting streets will also be employed in blocks devoted to business or manufacturing purposes, unless special reasons apply. For certain purposes the

whole block may be used. One of the objections made to the plan of upper New York is that the main streets are so close that sufficient continuous building space is not always available.

The reserve area in the center of each unit will cover about 18 acres. Details of a unit area are shown in Fig. 2; details of blocks are shown in Figs. 3 and 4.

It is, however, underground Protopolis that embodies the most radical departure from established methods. No resident of a large city needs to be reminded of the expense and annoyance due to the underground systems necessary in modern life. The complex and extensive network of pipes and wires represents an enormous capitalization for initial construction and a still greater capitalization for the

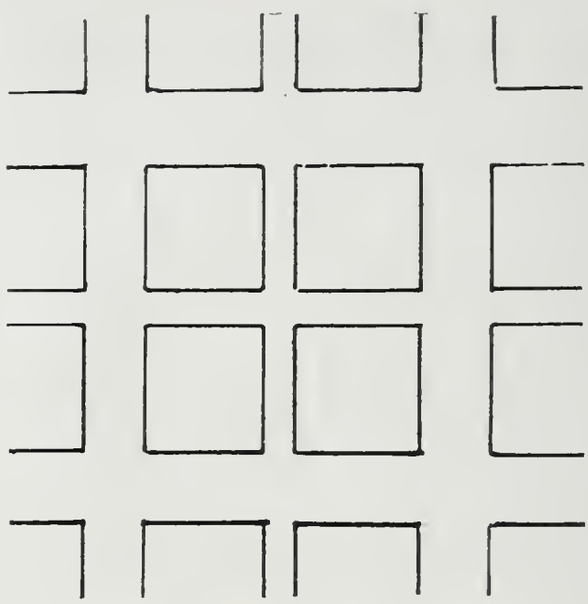


Fig. 3.

extension and repairs. It must also seem to many that the practice of excavating large areas for house use and yet leaving the street prism undisturbed, except when underground systems are to be installed, is most wasteful. It must be borne in mind that the dangerous and disfiguring overhead electric systems are entirely due to the cost that the excavation of the street prism involves.

The simple remedy is to build up from the established datum instead of digging into it. The entire city should be, so to speak, on stilts; that is, the street surface should be like the surface floors of ordinary houses, not resting directly on solid ground. Among the first persons to suggest this plan was Dr. B. W. Richardson, a distinguished English sanitarian of the latter part of the last century, who recommended it in connection with an elaborate plan for the

building of a sanitary city. Mr. W. Copeland Furber made independently the same suggestion some years ago at a meeting of the Club. In the years since Dr. Richardson propounded his views great changes have been made in the methods of municipal administration, and many new problems, especially those connected with underground construction, have been developed. The application of concrete has simplified many features of construction, and there seems to be no serious reason against the adoption of the method. Consider what would be the comfort of a city in which no street excavation took place and almost no street repair. It is intended that street surfaces in Protopolis shall be similar to those used for the best footways. No asphalt, wood-blocks, vitrified brick or Belgian blocks will be

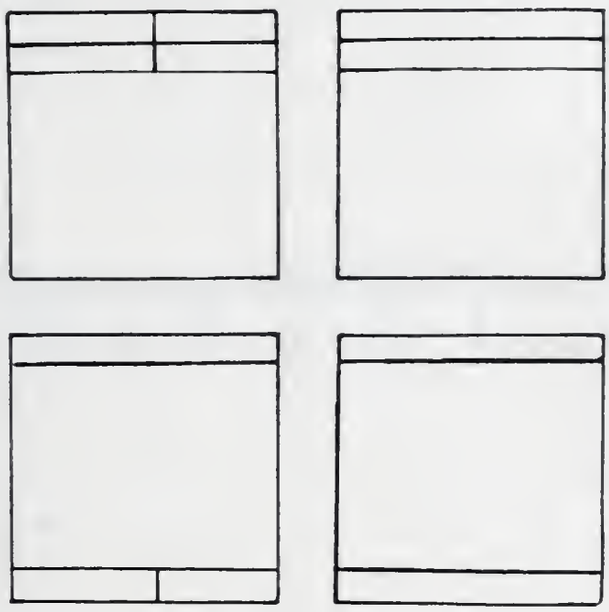


Fig. 4.

used, for no draft animal will appear on the streets. The horse is out of date for such purpose. All vehicles in Protopolis will be machine-driven—electric, internal combustion engine or any other source of power. The extensive area beneath the street, stretching from house line to house line, will afford room for all subway installation and for freight traffic. Of course, under the houses will be the usual cellar space. It follows, therefore, that no overhead construction will be allowed. There will be no necessity for surface tracks. The suburban connections will run underground or in a few places overhead. Communications at short distances will be carried out by automobiles. Interruptions of traffic will be far less frequent, as not only will many of the causes of such interruption be eliminated, but the vehicle can easily turn out of the way or seek another street.

Fig. 5 is a rough drawing, showing the plan of construction. No city of importance is now without its central lighting and power plant, water-supply, and sewerage, but in the model city central refrigerating and heating plants will be installed.

As an incidental result of the city plan, attention is called to the value of the non-traffic streets as playgrounds. The problem of playgrounds is regarded as one of great moment, and many cities are preparing to spend considerable money for establishing playgrounds. It is important, however, that such areas should be near the residences of those who use them. Playgrounds at a distance, however attractively laid out and equipped, can be of only spasmodic usefulness. On this account the traffic streets continue to be used largely in all cities. Children are put in peril, pedestrians are annoyed and imperiled, and traffic is disturbed. With the excitable foreign populations that throng the congested districts of our cities, injury to a child by a street-car often provokes a local riot. The rough sketch (Fig. 4) of the arrangement of house lines with regard to the non-

Fig. 5.

traffic streets shows two areas in each block in which no house frontage exists . These areas (50 by 175) will be suitable for local playgrounds. As only the sides of the houses touch on them, no serious inconvenience will be felt by the residents, and the termini of each area can be closed by stout wire netting, so that those outside will not be in peril. These two areas will be sufficient for the needs of the residents of the block. The non-traffic street on which the houses face would be reserved for quiet recreation, especially for very young children. No playing would be allowed on the regular traffic streets.

Elevated railroads would not be entirely suppressed in Protopolis. Some of the 100 feet wide streets would be occupied by them, especially by the main lines handling the freight. As all train movement would be by smokeless engines, the slow-moving freight trains would produce little annoyance. The several features of city life would be carefully classified. One section would be set apart for manufacturing; another for general business, amusement, and institutions of learning; another for high-class residences, another for residences of the humbler order. The horrible mixture of mills, business houses,

high- and low-class residences, which is so marked a feature of Philadelphia would be avoided.

The engineering features of the model city could be discussed at much greater length, but time requires that something now be said as to the financing of the operation.

The financial management of American cities is a stench in the nostrils of decent people. Even the president of the United States, who is, or was until recently, an optimist, said a few years ago that if he was asked in what respect the development of the country had failed to realize the hopes of its founders he would place the failure to secure proper government of cities as one of the most disappointing events. Everywhere in American cities we see extravagance, neglect, stupidity. All of them are borrowing money for necessary improvements, yet there is no doubt that with proper management a modern city can be operated at a profit and yet give its citizens better accommodations than any American city gives.

A remedy for these troubles would be to make the entire city a business enterprise. The whole area should be owned by the corporation, under which the construction should take place. Such a corporation would, of course, require a large capitalization, but large sums are no longer startling. A capital of $100,000,000 is a trifle in modern finance, particularly when a fair return is assured. It is not possible to go into details, but it may be pointed out that an essential feature would be that no land should be sold. The corporation must retain control of every part of the territory, and thus secure the increment of value which the increase of population necessarily brings. Land may be leased for a limited term, subject to the most stringent building restrictions, so that the city plan may not be disturbed. In proportion as the necessity for street construction arises, the additional capital can be easily obtained. Residents of the city might be allotted a limited amount of the stock, but not enough to secure to them control of the corporation.

It is obvious that the success of this enterprise involves a not inconsiderable degree of altruism. This may be considered by many a serious objection, but there seems to be only two methods of solving the municipal problem. One is to transfer all ownership to the public at large, namely, socialism; the other is to establish a benevolent feudalism with an element of what has been called "enlightened self-interest."

However utopian and even fantastic these plans for the model city

may seem, it is evident that there is a serious striving for some plan for the betterment of municipal life.

DISCUSSION.

John C. Trautwine, Jr.—Respecting original and unconventional expressions, Emerson says: "The sentiment they instil is of more value than any thought they may contain"; and Dr. Leffmann's paper interests me less as a method of planning streets than as an indication of the progress (or retrogression) of humanity from the ancient individualism under which cities grew haphazard (as illustrated by the plan of ancient London) toward that inevitable socialism, or communism, or collectivism, under which cities, like all other matters, will be designed in advance by a central authority, representing "the common sense of most."

The present advanced stage of our progress in this direction is illustrated by such cities as Berlin, where the imperial will insists upon civic beauty, and where paternalism sees to it that buildings are so constructed that the occupants shall not be deprived of that supply of light and fresh air which is essential to their health, which means the health of the community. At this rate, how long will it be, before the community similarly insists that each of its members (and not alone its soldiers) shall be sufficiently and properly fed and clothed?

Dr. Leffmann struck the key-note when he said that, for efficiency, there must be a boss, as witness the contrast between ancient, bossless London, and modern, bossful Berlin. The only question is, who shall be the boss? and we look forward hopefully to the day when the whole people shall have acquired such virtue and intelligence as shall make them their own boss and shall make a republican form of government possible.

But our methods are still largely individualistic, and, under this condition, how is it possible to design a city intelligently? The great manufacturing corporation can, to a certain extent, foresee its future, which is, relatively, in its own hands, and it has this great advantage in planning its "toy village" for its employees, but, with the development of industry left to the tender mercies of the mob, as at present, who can tell, in advance, in planning a city, what provision to make for this, that, and the other contingency? The "toy village" is planned for the next twenty-five, fifty, or hundred years. A city's life is measured in centuries; and, in a civilized community, a decade now brings greater changes than does "a cycle in Cathay."

As Dr. Leffmann assures us: "We are now capable of dealing satisfactorily with all the problems of transportation, etc." (satisfactorily, as judged by our present standards), but who is even yet capable of foreseeing the requirements of the city of the year 2010?

When the plans for the improvement of Philadelphia's water-supply were under discussion, in 1899, Mayor Ashbridge urged that the new plant be made sufficient for the needs of the next half-century or century. The desire was praiseworthy; but those who have any conception of the rapid advance of sanitary science will perceive the greater wisdom of providing present works for the supply of only the near future, with provision for necessary extensions to be made (when the time comes) in accordance with the development of our knowledge.

A little more than a century ago, Philadelphia rejoiced in all the priceless blessings of individualism in its water-supply. Each family had its own well and pump, through which it received the seepage from its own and its neighbors' privies, and the city was repeatedly scourged by yellow fever.

To-day, socialism has deprived us of these blessings, destroying individual competition and individual liberty, even forbidding me to use my own pump, if I have one. The competition is now between city and city; and we see these communities reaching out, in competition, after coveted sources of supply; but this unseemly squabbling promises to work its own cure. In Massachusetts already the Metropolitan Water Board manages the water-supply, not of Boston alone, but of Boston and other towns; and New York's quarter-billion dollar Catskill aqueduct must surely be made to supply many of the populous towns along its line.

Thus all public utilities (and what utilities are not public?) are rapidly coming under the control of authority more and more nearly central; and the central authority is thus acquiring the knowledge which, one day, will locate all the various industries of our country, or of civilization, to the best advantage of all the people, and will intelligently plan our cities, if there be in those days anything corresponding to our present notion of a city.

Dr. Leffmann's remark that "A modern city can be operated at a profit" nearly repeats the recent expression of Mayor Reyburn: "Philadelphia gets as much, for the money she spends, as any great corporation in America." Why should she not? As a city, her million and a half of people, instead of wasting their energies in competition against each other, act as a unit, each applying a ridiculously small part of his income to the providing of municipal benefits for all. Every practical man must see that this spells wealth.

Dr. Leffmann is responsible for the statement that "the financial management of American cities is a stench in the nostrils of decent people"; but this stench tells us, more loudly than words, of the advantage derived from what we already enjoy of municipal socialism, without whose splendid economies, our cities could not stagger on, under their loads of graft, miscalled "political," and due solely to our persisting remnant of individualism.

B. A. Haldeman.—It seems to me, if the Club undertakes a series of discussions on the subject of city planning, such discussions should not be confined to the planning of a new, ideal city. Ideals change with the passing years; Philadelphia was an ideal city when it was planned by William Penn in the closing years of the seventeenth century, but it falls far short of the twentieth century ideal. Instead of dreaming of ideals let us turn our thoughts seriously to making such improvements to the city we already have as are necessary to keep it abreast of the progress of the age. Even though an ideal city could be planned and built as suggested by Dr. Leffmann, it would probably be impossible to induce the people of an existing city to remove to it.

The creation of a city is a process which extends through many generations, and each succeeding generation brings new conditions, new necessities, and new responsibilities which must be wisely provided for if the city is to thrive and prosper. This is the great lesson taught by Paris, which holds the proud distinction of being the world's most beautiful city only because she has been undergoing a constant and intelligently planned transformation during the past four

centuries, and only a year ago she appropriated one hundred and eighty millions of dollars for further improvement, largely because her prestige was being seriously threatened by Berlin, Vienna, and Budapest, all of which, together with many other Continental cities, have been practically rebuilt along modern lines during the past forty years. That such replanning and rebuilding of those cities has been a wise public policy is abundantly proved by their marvelous industrial and commercial progress in recent years, and by the fact that travelers in steadily increasing numbers are attracted to them from every corner of the civilized world. The material prosperity of such cities is one of the best arguments that can be put forward in favor of similar work of reconstruction in our own cities, and it is emphasized in our own country by what Boston, New York, Chicago, and many of our smaller cities have done and are doing.

Boston has a club consisting of several thousand of her best citizens all working for a "Greater Boston." There are some thirty committees, each studying a separate problem of improvement, but all striving to make their city the finest in the world, and they are all enthusiastic in the claim that they will have accomplished that object in the year 1915. New York is conducting vast operations for joining together all parts of the greater city and for making it more attractive and more world-famous. The Commercial Club of Chicago has paid eighty thousand dollars for the preparation of a plan for a great transformation of that city; the plan is so ambitious that it is doubtful whether it can all be accomplished, but the physical changes involved in it have been commenced.

Berlin is a city without slums, and the same may be said of other German cities. Twenty-five years ago the working-people of Berlin lived in cellars and caves; to-day they are probably the best housed working-people in the world. This change is due to the intelligent replanning and rebuilding of the older parts of the city and to the improved methods in making extensions. It seems that the Germans have been much more successful in solving difficult municipal problems than we have; I understand there are about fifteen hundred towns and villages in Germany in which the people pay no local taxes, the income derived from property and public service utilities owned by the communities being sufficient to meet all expenses and, in some five hundred towns, to pay dividends to the citizens.

I hope the Philadelphia Chapter of the American Institute of Architects and the Engineers' Club may see their way clear to join hands in the matter of city planning, and that they may be able to evolve some practical methods for the further improvements and development of the city along such intelligent and broad-gage lines as the rapid pace of twentieth century progress seems to demand. I do not know how keen an interest the members of the Club feel in this subject; engineers are somewhat migratory in their habits, more from necessity than choice perhaps, but most of us have our homes here and hope to remain here for some time at least, and we should all enter earnestly into the study of this problem, for the future position of Philadelphia in the list of the world's great cities depends to a very large extent upon its wise solution.

Paper No. 1094.

MILITARY ENGINEERING.

CAPT. C. W. OTWELL (CORPS OF ENGINEERS, U. S. ARMY).
(Visitor.)

Read October 15, 1910.

Military engineering sprang up with strife, and strife began when Adam made his transgression and received the curse of the Almighty, to earn his bread by the sweat of his brow. He was compelled to fortify himself against the cold by the growing of wool, against the pangs of hunger by tilling the soil, against the wild beasts of the field by the rearing of walls, and against the burning sun and the falling rain by the building of roofs. All this seemed natural enough, but when selfishness sprang up and brother sought the life of brother, minds were stirred to devise methods of defense. Cain built around his city, Enoch, on the Mount of Libau, a wall which was the beginning of fortification. The walls of Babylon, of Jerusalem, Tyre, Troy, and Carthage were but the development of this idea of the necessity of protection. A study of history will show that that nation ruled which made the best use of engineering devices, not only for defense but also for aggression.

With the lapse of time has come progress in the art of attack, and this has, of course, brought forth stronger and stronger types of walls. Each advance in method of attack has been met by a counter-invention for defense, so that the defense always has an advantage over the attack. The attack is sure to succeed only because it is prosecuted regardless of cost. Stones, spears, swords, ballista, catapults, smooth-bore guns, rifles, and explosive shell have each in turn caused the invention of appropriate methods of resistance.

For centuries the walls had the decided advantage, but the catapult, invented by the Syrians, ballista, invented by the Phœnicians, and the battering ram, seemed to mark the limit of progress in the weapons for attack until 1320 A. D., when a monk, Bartholdus Schwartz, discovered the formula for gunpowder. The arrows and large stones of the attackers and the hot pitch of the defenders had to be discarded and new implements devised. The tall towers on the walls which

were used for the defense of the ditches were found to be short work for a single shot of the cannon, which did more execution in a moment than did the continuous battering of the rams manned by hundreds of men. The increased range of powder-propelled bullets compelled the attack to begin at a greater distance from the line of defense.

Coming to this country, it is found that in the original colonies there were few opportunities for the development of military engineering. During the Revolutionary War dependence was placed on the foreigners, principally the French, for the engineering work required. After the war, came the reorganization of the army, when General Washington recommended the establishment of a school where the art of fortification could be learned.

It is known that in 1802, when President Jefferson signed the bill establishing the United States Military Academy, he, being of decided anti-army prejudices, did so with the idea of lending national aid toward education in the practical sciences, a knowledge of which he realized would be necessary for the development of the country. Until 1825 West Point was the only school teaching the practical sciences. In the year mentioned Rensselaeer Polytechnic School was founded, and the next to be established was Sheffield, in 1847. Since the Military Academy was the only source of supply of engineers, it will be found that almost all of the pioneer civil engineering of the country was done by its graduates.

By the time of the War of 1812 the Academy was giving a good account of itself, for its graduates had been engaged in placing the seaports in a defensive condition. In that war the first reverse in the northwest to the British arms (which seemed destined to be uniformly successful) was at Fort Meigs, where Captain Gratiot, and after his death Captain Wood, put into practice the principles learned, and so fortified the place by stockades and traverses that the British were forced to withdraw and General Harrison was enabled to take the offensive. In the defense of Fort Erie, following its capture by the American troops, it was a graduate in the art of fortification who led what Napier calls the only instance in history where a besieged force was able, by a single sortie, to break up a siege.

From this war until the Mexican War the graduates were engaged in carrying out the wishes of Congress in the way of exploration, railroad and canal location and construction, and in continuing the defenses of our seaports. Some of the graduates were loaned to colleges, some resigned to engage in instruction at other institutions,

and many engaged in civil pursuits. The Baltimore and Ohio Railroad was located and largely constructed by engineer officers. The now Northern Central, Erie, and Boston and Albany, were the projects of McNeil and Whistler; the latter having been later chosen by the Russians to build their first railroad from Moscow to St. Petersburg. Alexander Dallas Bache, a graduate of 1825, reorganized the Coast and Geodetic Survey. Benjamin H. Wright built the first railroad in Cuba and Talcott the first one in Mexico. Eugene Griffin, formerly general manager of the General Electric Company, may be called the father of the electric street railway, for it was his report, comprehensive and scientific, from an economic as well as a strictly engineering standpoint, which was the beginning of the movement for that class of frequent, cheap, accessible and quick transportation which is to-day one of our greatest national blessings.

The essential quality demanded of a military engineer is familiarity with certain principles. He is more apt to find himself in a place practically destitute of resources than in one where every facility is at hand. The United States Military Academy training is based on this theory. It would be a manifest impossibility to educate in all the specialties liable to be encountered in practice. The problem of the military engineer is ordinarily not like that of the civil engineer—carefully choosing materials and plant in order to do the work in the most economical method; but rather of doing his task with whatever material, labor, and tools may happen to be available. Often railroad iron must take the place of beams; cornstalks, poles, and straw the place of boards; wooden pins the place of nails; vines the place of rope, and an apparent nothing the place of a very large something badly needed. To carry the material and plant necessary to prosecute most economically any and every kind of work likely to be encountered would require an impossible amount of transportation.

The English word "engineer" is a comparatively modern term, and was first applied in the military sense only; Captain John Rudd, in 1650, being known as "Chief Engineer." The word succeeded the words "trench-master" and "camp-master." The general understanding of the term was "an officer skilled in the art of attack and defense of fortified places." The art of fortification involved so many other arts that the engineer was necessarily compelled to familiarize himself with many branches of what is now called "civil engineering." Water-supply, roads, disposal of waste, mining, and various works of construction were essential in order to make the

most of any situation in the attack or defense of a locality. Along with the development of these various branches, and the better application of the science to the use of communities in time of peace, came an awakening of the possibilities for civil use of a profession embracing these principles. The development of strictly civil engineering may be said to date from the middle of the last century, somewhat over fifty years. In time of war the duties of the engineers vary with the particular portion of the army to which they may be attached, and in order to understand their function it is best to begin with the organization of the army and the duties laid down by the regulations.

As defined by the Army Regulations, the duties of the engineers consist of "reconnoitering and surveying for military purposes, including the laying out of camps; selection of sites and formation of plans and estimates for military defenses; construction and repair of fortifications and their accessories; the supervision of the location of all buildings within one mile of any fortification; the installation of electric power plants and electric power cables connected with seacoast batteries, and furnishing the necessary electrical supplies connected therewith; planning and superintending of defensive or offensive works of troops in the field; examination of routes of communication for supplies and for military movements; construction and repair of military roads, railroads, and bridges; military demolitions; execution of river and harbor improvements assigned to it and such other duties as the President or Congress may order." The latter clause has included many duties, which now comprise the superintendence of the public buildings and grounds of the District of Columbia, the Lake Survey, construction work in the Yellowstone Park, construction and repair of lighthouses (which is soon to be taken over by a bureau of the Department of Commerce and Labor), commissionership of the District of Columbia, California Debris Commission, and the construction of the Panama Canal.

As to the duties in the field, few references are made in the Field Service Regulations except those to be understood by implication from those laid down for the chief engineer of an army. His duties are described thus: He "exercises general supervision over engineer troops serving therewith, and over engineer operations, including the preparation and reproduction of field maps. He assists in the selection of defensive positions, supervises the location and design of the field works, and may be charged with the construction of the

more important fortifications; he has general charge of the engineering features of siege operations, the construction and maintenance of military roads, bridges, piers and wharves, and the construction, maintenance, and operation of railroads under military control; he supervises the demolitions ordered by the commander, and the laying out and preparation of permanent camps. To carry out his duties he should have the necessary military assistants, ample funds, and authority to employ civilian labor, etc. Requisitions for funds, disbursements, and the care and disposal of property pertaining to the work in charge of engineer officers is subject to the regulations prescribed for the government of the Engineer Department."

The regulations give instructions as to map-making and scales and as to the diaries to be kept by organizations. Under the heading "Service for the security of the army" it is stated that "engineer troops are detailed when required," and "engineers are usually attached to an advance guard to remove obstacles, repair roads, etc." "Circumstances may also require a bridge train to be attached." The description of the typical formation of an advance guard for an independent division includes one company of engineers. The mounted detachment of the engineers is placed with the support of the advance guard, and the dismounted portion of the company with the reserve of the advance guard.

On the subject of the rear guard it is stated that "engineers are generally necessary to render the roads and bridges impassable and to throw obstacles in the way of the pursuing force of the enemy." It further states that "demolitions and obstructions are prepared by the engineers, assisted, if necessary, by other troops detailed from the reserve, and completed by the mounted engineers of the rear party at the last moment. Instructions of the supreme commander govern in the demolition of important structures." "Engineers are usually attached to the outpost to assist in constructing intrenchments, clearing the field of fire, and opening communications laterally and to the rear." "During the preparatory stage (for combat) the engineers open roads to facilitate lateral communication and to enable the artillery to move rapidly to the front when an advance of that arm becomes desirable." "Night attacks are made mainly by the infantry. Engineers are added when obstacles are to be removed or surmounted." On the defensive it is stated: "If possible, a reconnaissance should be made by the commander in person, accompanied by officers of the general staff, artillery and engineers." In

prescribing the distribution of troops for the defense it is stated: "The engineers are employed in opening roads, clearing the field of fire, constructing barbed wire entanglements, setting up and operating searchlights, and otherwise strengthening the position. Engineer officers outline the trenches and other works and, if practicable, supervise their construction by other troops."

To accomplish these various duties there are the officers of the regular corps of engineers, three battalions of regular engineer troops, the engineers of the organized militia, and the volunteer engineers organized when a state of war exists; these engineer troops are assisted by details from the line, and in some cases civilians are hired. The regular corps of engineers consists of 188 officers. Of these, a portion are on duty with the three battalions of regular engineers and others are on duty detached from these troops. Of those detached, the greater number are engaged on seacoast fortification work, having at the same time in their charge the river and harbor improvement and lighthouse construction in their respective districts. Some of the officers are engaged on river and harbor work exclusively.

In the organized militia there are the following engineers: viz.: one regiment in New York, two companies in Pennsylvania, one battalion in Ohio, one company in Michigan, and an organization, of which the details are not known, in Oklahoma. The progress of their instruction varies with the organization; most of them have been organized but recently.

In order to understand the relation of the engineers to all the forces, the following outline of the organization of the latter is given. The national forces are made up of *armies*. An army is composed of two or more *field* armies. A field army consists of two or more *divisions* and certain auxiliary troops; this unit takes the place of the corps of former days. The division is the smallest unit capable of independent action; that is, which has all classes of troops, including infantry, cavalry, field artillery, signal troops, hospital corps, engineers, and a supply organization. It consists of its own headquarters, three brigades of infantry, one regiment of cavalry, one brigade of field artillery, four ambulance companies, one battalion of signal troops, four field hospitals, one pioneer battalion of engineers, and the necessary supply organization. This organization is not really complete, for it lacks a ponton bridge equipment; which would, however, be attached in case the division was sent where such material was required. There is a ponton battalion at the headquarters of the

field army which is kept in hand to be sent where needed, for it is probable that all the divisions would not require all the equipage at the same time. To the field army is also attached the engineer park, consisting of tools, such as picks, shovels, axes, and saws, and of materials, such as explosive, wire, rope, iron, etc.

There is also a cavalry division, which differs from the organization of the division above outlined in that all the troops are mounted and the hospital attendance is but half as large. The battalion of mounted engineers consists of three companies of only one hundred enlisted strength each. There are at present no mounted companies in the service, but in some of the pioneer companies there is a mounted

Fig. 1.—Japanese engineer pack train.

section consisting of one first lieutenant and twenty-four enlisted men. Each pioneer company consists of one captain, two first lieutenants, one second lieutenant, and one hundred sixty-four enlisted men, including the mounted section.

The engineer equipment of the pioneer company is carried in three tool-wagons and on six pack mules. This allowance of transportation is small, as it must necessarily be, since the train of one division is about fifteen miles long, the field train alone taking up over two miles of road. Every effort is therefore necessary in choosing tools which shall be light and pack well, but still be strong and serviceable. For the tools there is a wagon now undergoing trial which seems to

be able to hold all the tools and a portion of the supplies; it is the design of Major Thomas H. Rees, Corps of Engineers. The pack mules are generally with the mounted section, and they carry complete carpenter, pioneer and intrenching, demolition, and supply outfits.

As a general rule, an army in the presence of the enemy advances with divisions (consisting of about 17,000 men each) in column, abreast of one another, and marches on parallel roads three to five miles apart. It proceeds with a cavalry screen thrown out to the front to get information about the enemy. This screen is about two days' march ahead of the advance guard. The advance guard consists of troops pushed out well to the front of the main body for the purpose of insuring the safe advance of the latter, by clearing the roads and brushing aside any small parties of the enemy; or, if he be in force, to hold him in check until the main body can take up the battle formation. The main body is about two miles back of the advance guard.

As before stated, there is at present no prescribed position for the engineers, but it is presumed that there will be with the cavalry screen one mounted battalion of engineers and probably some of the light bridge equipage. To the advance guard there will be attached the mounted sections of one or even all of the three companies of the battalion of engineers belonging to the division. Should the nature of the country in which the army is operating require considerable work on the roads, one or more companies would be attached to the reserve of the advance guard.

Having outlined the general location of the engineers with the forces, the subject of military engineering will be considered in detail under the following headings, viz.: reconnaissance, roads, bridges, demolitions, railroads, castramentation, fortification (including sea-coast, provisional, and field) and river and harbor improvement. In studying the requirements under these heads one finds that they vary with the particular stage of the military operations; in time of peace there is as much necessity for training as there is for activity in time of war.

Reconnaissance is a term applied to the work of troops or individuals in gathering military information in the field. The engineers are principally concerned in making reconnaissance of the topography, hence what follows will be understood to apply to topographic reconnaissance.

It is known that the ancient warriors had some means of repre-

senting the lay of the ground. While few records remained after the destruction of Carthage, history records that Hannibal always completed his reconnaissance in person. The beginning of the development of the art of map-making as applied to military operations was during the French Revolution. It was the maps which Carnot, himself a graduate military engineer, had had prepared by the topographic engineers, organized as a result of experience gained in the revolution, which enabled him to send out and keep in the field fourteen armies in as many directions. His strategy, however, was as poor as his mapping was good.

There is considerable difference between civil and military practice, both as to maps themselves and as to the manner of their making; the nearest resemblance to the military maps being those used in railroad location. Generally speaking, the civil survey shows relative locations; the military map must go more into detail. An army must know where it can find forage, fuel, water, and food for its existence. To coördinate an advance it is necessary to know the length of time required to pass over the various distances, which condition demands that there be known the rivers and their crossings, the location and character of the roads as to both grade and nature of the roadbed. In marching to the attack, it is necessary to know how the advance can be made out of sight of the enemy and protected from his bullets. These requirements demand that the hills, woods, and growing crops be shown.

Upon consideration it is also apparent that the character of the reconnaissance will vary with the particular state of the advance. While the nature of the duties required of the mounted engineers will depend on the nature of the country, it is probable that they will have sent in sketches of the roads in the front. While these may not be contoured, they will have all the roads, and these road sketches, together with the civil maps ordinarily obtainable, will form the basis for assigning the work of the more detailed reconnaissance. It is important that the work be well apportioned, not only according to the difficulty of the ground, but also with due consideration as to the abilities of the sketchers. The sketches must all be turned in at practically the same time. The director proceeds along the road, or other line which he takes for his control line, and posts at each cross-road suitably marked cards giving the elevation and indicating the number of the sketcher designated to cover the outbranching roads.

The sketchers map about three to four hundred yards on each side of the road.

Early charts or maps gave little indication as to the relative elevations of various parts of the ground, and the development to our present method was slow. Hills were first indicated, if at all, by hachures, the weight and closeness of the elements being proportioned to the steepness of the slopes. It was Whistler, of the class of 1819, West Point, who, if he did not invent, did first practise representing elevations and slopes by means of contours. By fixing the contour interval for a certain scale, and varying the interval inversely with the scale, the distance between contours on a given slope will always be the same. This is a great advantage to the military man, for he is able to train his eye to associating the closeness of contours with the various slopes, and can thus read at a glance whether the ground is favorable or otherwise for the advance of troops of the different arms. In the United States service an interval of 20 feet is used for the scale of 3 inches to one mile, that is, 1 to 21,120; 10 feet interval for the scale 6 inches equal one mile, and so forth. The sketcher, having determined a slope along a certain course, is able to plot a series of contours, he having by practice become accustomed to the distances between contours for that slope; and, knowing the horizontal distance moved along that slope, he can at once plot any point on the course, and noting the contours between which it lies, read the elevation of that point. The horizontal distance between contours of a given slope is, when plotted to scale on the map, called the "map distance" for that slope. A scale of such map distances can be readily constructed by the formula:

$$\text{Map Distance} = \text{Contour Interval} \times \text{Representative Fraction} \div \text{Tangent of Slope.}$$

For the ordinary military sketching, directions are obtained with the compass, elevations by aneroid barometer, slopes either by the clinometer or simple slope board, distances by counting the strides of a man or by timing a horse. If possible, the control will be established by triangulation. All the instruments actually required are pencil, piece of paper, and a string; with these may be made what may be a very valuable sketch. A strip of the paper, torn with one edge straight, will serve for a ruler and a scale; a straight line (drawn by means of the string or the ruler) will give an angle of 180 degrees, and by subdividing this, a protractor may be made. This protractor and

the string, with any small weight tied to it, will serve for a slope board. The direction is carried by back-sighting, using the pencil as an alidade. The construction of the scale of distances and of map distances requires that the sketcher know the length of his stride and a certain distance, as one inch, on the paper. He should also know the various map distances of the contours, although this is not absolutely required, for he can construct the scale graphically by remembering that a radian is 57.3 degrees. It would seem that the results to be obtained with the simple instruments mentioned would not be of value, but it has been found that with training very close work is possible, the average man sketching about two miles per hour.

The method already described covers only the field of road sketching done on the advance. When the point is reached where it is presumed that the enemy will give battle, it then becomes necessary to make what is known as a position sketch. This requires more detailed information, and the scale is therefore increased to 6 inches equal one mile and the contour interval decreased to 10 feet. The control line is determined on, generally parallel to the front, and the director divides the front to be covered into areas about half a mile wide and two miles deep; that is, perpendicular to the front. To each of these areas is assigned a party of one chief sketcher and two assistant sketchers. The director marks, by stakes set along the control line, the points of divisions between the areas. Each stake has written on it the elevation of the point. The chief sketcher of each party sends his two assistants to the bounding stakes, one on each side of his area ,who there meet the corresponding members of the neighboring parties. The two sketchers, one from each of the bordering areas, make a sketch (one only) of the area along the boundary-line, taking in a strip about 300 yards wide in each area. The chief having sketched in the portion along the control line proceeds to the end toward which his sketchers are working and gets them together at that end. They having arrived at the end of their strips, actually cut the sketch, which it will be remembered contains a strip from each area, along the boundary, and each sketcher takes to his chief his portion of the sketch. The latter orients and places his own and his assistants' sketches in proper relative position and pastes them together. This leaves a strip about 200 yards wide down the center of the area which is not yet filled in, which is sketched in on returning to the control line. When all the sketches are collected, they are sure to go together, for the reason that they were, along the boun-

daries, one and the same piece of paper, and they all abut at one end on the control line. If all the sketches are made on transparent paper, a negative is immediately available. The position sketching is ordinarily done by the "division," and at the headquarters of this unit is carried a lithographic outfit, with the engineer battalion headquarters. The maps of the front of the various divisions are sent in to the field army headquarters and there united for the information of the commanding general in planning his attack or defense. After the army has passed well to the front, there follows in its rear a trained corps of civilians equipped with instruments of more precision, which has more time at its disposal. These men check the sketches prepared by the army on its advance and complete an accurate map of the territory.

Road building, of which bridge building is so large a part as to require separate treatment, differs from the ordinary civil work in that discomforts and in some cases noise are no particular detriment to the efficiency demanded. Grades may also be heavier for the temporary roads. The same rule holds for the military as for the civil road—"Good roof and dry cellar." The good roof in the military road consists chiefly in giving a high crown; the dry cellar, as in the civil road, is assured by good side ditches and good outlets for those ditches. Oftentimes swamps are encountered, and it then becomes necessary to corduroy with saplings and brush—the materials usually available. The character of the road making varies with the stage of the advance. Ordinarily the first step consists in clearing away the obstruction left in the path by the retreating enemy and to prepare the way for the combat trains. This work is partly done by the mounted pioneers of the cavalry screen and partly by the mounted sections of the advance guard. If there is a great amount of work required, the engineer troops will, upon information probably sent back by the cavalry, be assigned to the advance guard, so as to make the road sufficiently completed to permit the main column to pass. The character of the road work required with the pioneers of the advance guard will consist mainly of hasty repairs to culverts and bridges, cutting lateral or by-pass trails, corduroying soft places in the roadbed, and clearing roads which may have been obstructed by the enemy.

In constructing military roads the guiding principle for grades is to keep under 3 degrees from the horizontal, except that for short distances 6 degrees may be allowable. These grades are permissible

because military wagon trains travel in groups, and in case of necessity, teams can be doubled. In mountainous countries, where the pull is long, doubling up is not practicable, and in consequence the grade should be limited to 2 degrees, though occasional short stretches may run up to 4 degrees.

The maintenance of military roads does not differ from that for civil roads; the same rule applies—a shovelful of earth in time is likely to save a wagon-load. Each company carries as a part of its equipment a plow and a drag-scraper. The judicious use of these

Fig. 2.—Corduroy road built in Manchuria by Russians during late war.

will do wonders in drying out muddy roads. Most of the roads which an army will use on its advance, except those to which the enemy will be able to do little damage, will be of the earthen type. It was remarked by the military observers during the late Russo-Japanese War that the movements were very slow, not so much with the Russians, but very noticeably so with the Japanese. This was due largely to the character of the roads, which, until after the battle of Mukden, received little attention as to improvement. In the rainy season it was not an uncommon sight to see horses going through some of the

city streets walking in water and mud up to the points of their shoulders.

One of this country's assets in Cuba to-day, a result of the intervention, is a system of military roads built by the engineers of the Army of Cuban Pacification, partly by contract and partly by day labor. There is also a very good military map of Cuba in possession of the government as a result of the intervention.

Bridge building is one of the most important features in military operations. The famous pontoon bridges of Xerxes over the Hellespont (the shortest one being three-quarters of a mile in length) will retain the record for some time, it is believed. One feature of their construction is not particularly comforting to military engineers. Xerxes took to beheading his engineers because of bad luck, due to unforeseen difficulties in the shape of unavoidable accidents, which prevented the completion of the structures on time. Alexander's bridge across the Danube, 335 B. C., showed his striking ability. His floating bridge of dugouts, hides, and rafts of sundry descriptions inspired the Getæ with such awe that the subjugation of the barbarians of the northwest—one of the greatest problems left Alexander by his father—was accomplished without a single battle. Hannibal's crossing the Rhone, whereby he was able to flank the barbarians, was a clever piece of strategy. The passing of his main column, especially the elephants, was interesting. At first the elephants could not be induced to go onto the rafts, but finally they were put aboard after earth and vegetation had been scattered over the immense floats. However, after the rafts had been shoved off, some of the elephants fell overboard, and though their keepers drowned, due to the great concern lest their charges perish, the elephants simply walked across on the bottom, blowing water out through their trunks. Napoleon's lack of bridge equipage almost cost the destruction of his army at the Beresina, and his annihilation would have been almost certain had the Russians demolished the causeway over which the French right was compelled to advance. Julius Cæsar's famous bridge over the Rhine, supposedly near Bonn, was of a type very similar to what would be built to-day. One feature is noticeable—he placed fender piles on the up-stream side in order to afford protection against ice and floating objects which the enemy might launch against the structure. The most remarkable feat was the time it took him to build it; ten days for a pile bridge a quarter of a mile long would not be bad to-day.

Without a bridge equipage at his command, manned by a personnel

as efficient as ever existed, Grant, while advancing through Virginia's network of rivers in his campaign to crush the Confederacy, would have been powerless. He knew better than to attack Lee in the latter's field of greatest efficiency—fortifications—and chose to advance by flanking movements, every one of which required several river crossings to be constructed in haste. The ponton equipage met the demands very satisfactorily.

Military bridging may also be divided according to the portion of

Fig. 3.—Light bridge equipage ponton; one boat covered with canvas; another partially uncovered, showing frames.

the army which it accompanies. It has been shown how the army is preceded by the cavalry screen; the former must have an equipage which will enable its trains to pass any streams encountered and yet be light enough to keep up with the mounted column. This demand is met by the light ponton equipage, the pontons of which consist (Fig. 3) of knock-down frames covered with canvas. These pontons will sustain the heaviest weight carried by army transportation, except the siege guns, and there is no particular necessity for an army to carry siege material, because it is ordinarily carried far to the rear,

behind the reserve or heavy bridge equipage (of wooden pontons) which will meet any requirements for military service. Since the cavalry must keep moving to the front, it is necessary that the light bridge be taken up as soon as its trains have passed. This leaves the main body of the army not much better off than before, except that it has information, sent back by the cavalry screen, as to the nature of the country to be traversed. If this information indicates that a large stream is to be crossed, the heavy equipage is ordered to the front. But neither can this remain indefinitely, for the army keeps moving on, and there are always more rivers to cross. Consequently the finishing of the reserve bridge marks the time for beginning the semi-permanent pile or trestle bridge. With the completion of this bridge the reserve equipage is again free to rejoin the main column. The pile or trestle structure will ordinarily be permanent enough for the purposes of the war, but in some instances it may be necessary to make the bridge safe against ice or overflows, and it then becomes imperative to replace the pile bridge by a truss. The construction of the bridge at Fort Riley, Kansas, by the Third Battalion of Engineers, illustrates the successive stages of military bridge building. The bridge was of the Pratt type. All the tension members are wire cable; the ends of the roadway bearers and of the struts form the pins. The entire structure was built by soldier labor. It consists of eight 90-foot spans and the approaches. The trusses were built without interruption of traffic; the floor system of the temporary or pile bridge formed the same for the trussed bridge.

The particular type of bridge best to use depends on the local conditions, especially on the materials available, the nature of the banks and of the bottom, and the depth of water. For shallow streams the simple tripod or four-legged trestle type is best. Where the water is moderately deep and the bottom fairly solid, the two-legged type is used. Where the bottom is very soft, resort may be had to the pile bridge. In bridging deep chasms (a rather rarely encountered case) or where there are steep banks or poor bottom—especially when the latter is accompanied by swift current—the single-lock, double-lock, cantilever, king-post, queen-post, suspension or trussed types are used. The cantilever and single-lock are adapted to spans of not over 30 feet, the double lock and queen-post to spans between 40 and 50 feet. In any case where only one crossing of the army is required it may be more convenient to construct rafts. Trestle and pile bridges are, of course, adapted to any length, but they are not prac-

ticable for great depths of water or unusually steep banks, because piling and spars of the required length are generally not available near the site. Suspension bridges are well adapted to military operations in that the materials can be easily transported; this type is, of course, especially adapted to long spans. If the traffic requirements are heavy, the suspension bridge must be greatly strengthened or replaced by a truss.

For military bridging purposes most materials must be obtained at

Fig. 4.—Fort Riley, Kas. Bridge built by Third Battalion Engineers, U. S. A. Illustrating sequence of construction of military bridges, viz.: ponton, pile, and truss.

the site of the crossing, the only exception being fastenings. The most adaptable material for this purpose is rope, and for this reason all engineers should be well instructed in not only the making of knots and lashings but in the circumstances under which each should be used. Wire rope is also a material of great strength which can be readily packed. Hemp rope, while light and well adapted to military uses, possesses the disadvantage of being affected by moisture; joints made fast with it require constant attention during alternating wet and dry weather. As a result of the observations made during

the late war between the Russians and the Japanese, experiments have been made in our service with a view to ascertaining whether iron could be advantageously used as a fastening. The Japanese used iron timber-dogs in many of their bridges, and with apparently satisfactory results. Experiments made at Washington Barracks seemed to indicate that they were not economical either as to strength or as to ease of transportation; they have weak parts at the shoulders and they are quite unhandy to pack. The results of the experiments so far made indicate that strap-iron is well adapted for our use in making fastenings. The objection that it was impossible to make a tight joint was overcome by using a block of wood under the center of the strap, drawing the strap tight over this block, and then making it as tight as desired by driving nails or spikes between the block and end nails. Where pieces cross, as is the case in the military trestles, the task of making a tight joint is an easy one, for one spar acts the part of the block of wood. The iron straps are issued in three lengths —6 feet, 3 feet, and 1½ feet; the idea is to use the longer ones as loops to hang the roadway bearer, the medium lengths for drawing the joints together, and the shortest ones to prevent longitudinal displacement.

Demolitions form a very important branch of engineering in the field. The principal work of this character consists in destroying bridges and railroads. Occasionally it is necessary to demolish structures which interfere with the field of fire in front of a defensive position. The obstacles of the enemy also require removal, and it is desirable to know the best method to attack them. One rule to be borne in mind is that before making demolitions of objects which have a value for purposes other than the military, the authority of the supreme commander is required. This rule is subject to the one exception that self-preservation warrants such steps as are necessary, that being the first law of nature. For example, a small force being hard pressed would, of course, be justified in destroying a bridge in order to delay the enemy.

There are several methods used in executing demolitions—fire, blasting, and mechanical means. Fire is a thorough destroyer of things which are composed totally of inflammables, and of which the parts are in proper relation, such as clothing, food, and some building materials. However, in bridges and other structures consisting largely of fireproof material fire is of use only to inflict temporary damage. Stuart's raid around McClellan's rear and the destruction

of the immense quantity of supplies at the latter's base is an example of the effective use of fire. The destruction of the Capitol buildings in the War of 1812 was a shameful use of fire, and will always be a disgrace to the British arms, having been committed for revenge of a fancied grievance.

In our service the present adopted type of explosive is rack-a-rock. This was chosen since neither the chlorate of potash nor the nitrobenzol is explosive by itself, but when mixed they make a powerful destroying agent. They are carried separate and the potash soaked

Fig. 5.—Military bridge, showing, from the right, two-legged trestle (two bents), four-legged trestle (two bents), tripod (one bent), and lowering of the trestles for single lock (to form the next two bays).

in the benzol at the spot where the explosive is to be used. It has been found that the powder escapes out of the cloth bags in which it is carried in the pack demolition outfit, and another explosive, safe but powerful, is being considered.

The interruption of traffic on a railroad, even in a hostile country, is a practical maneuver, provided the work of demolition be done expeditiously and well. A very small force is required; one man with a few sticks of dynamite can, if he knows the advantageous points of attack, do more damage to a bridge in a few minutes than a regiment can repair in a month. Railroads are temporarily disabled by over-

turning the track or by sliding sections of it down the embankments or by carrying away portions of it (in case the railroad is being abandoned). In the earlier stages of the Civil War the Confederates tried these methods for infliction of permanent damage, but almost before the damage was done the Federal trains were running over the track again. They then tried heating the rails and bending them in the center. This was better, but they could be straightened again. They did not seem to be as resourceful as were the Federals in this kind of demolition work. It would seem that the thought would have occurred to anybody that the quickest method of tearing rails loose from the ties would be the use of a powerful lever working at right angles to the rail, but it required considerable time to evolve the simple apparatus consisting of a U-shaped iron with claws on the branches, which was caught under the base of the rail and through which the end of the long lever, held upright, was passed, the fulcrum being a block of wood placed against the head of the rail. One of these at each end of the rail tore it loose in a single pull. This same apparatus was found to be the most satisfactory for completely putting the rails out of commission, by twisting them; for this purpose one of the levers was placed on the opposite side and pulled in the opposite direction. Once treated in this manner, there was but one way to fit the rail for service again—send it to the mill and re-roll it. In the advance of the Fifth Army Corps on Santiago, it was found that the demolition of the railroad stock at Siboney, executed by the retreating Spaniards, consisted of throwing the pistons and cylinder heads of the locomotives into the tall grass. The inquisitiveness of the American soldier discovered the missing parts, and the locomotives were soon being used to forward the troops, but principally (the fact most clearly appreciated by the author) for bringing up the rations. A locomotive can best be destroyed by firing a cannon shot through the boiler. The ordinary method—the one which nine out of ten engineers or firemen will suggest—is to build a fire under the boiler after having drained off all the water. It is found, however, that in practice this method is not very effective, for the reason that the damage is almost always overestimated, and the enemy can usually plug the tubes or arrange some way to make the engine run. The ordinary run of other rolling stock is principally of wood, and fire is the best means of destruction.

In the destruction of bridges it requires an intimate knowledge of the critical points in the various types. The general rule to remember

is, of course, that the tension on the chord is greatest at the center and the shear is greatest at the abutment. In some of the types the stability of the entire structure hinges on one or two members. Take, for example, the Howe truss; destroy the main braces at one end, and the bridge falls. In the Philippines the insurrectos in retreating north along the Manila and Dagupan Railroad did quite effective work in destroying it, and it fell to the lot of the engineers to restore the road to a serviceable condition. This work included building

FIG. 6.—Bridge of tripod supports; used in shallow water; hard, even bottom.

miles of track, rescue of several locomotives from the depths of streams, reconstruction of the rolling stock, reconstruction of several bridges, and the operation of the road until the owners were in position to resume control.

Military railroad work in time of war may be divided into domestic and field operation. When one considers how short is the effective transporting radius of a team of mules away from its base of supplies (owing to the fact that the daily requirements of forage are about one

hundred pounds), it is appreciated how important it is that the base of supply should be well up toward the head of the advancing army. Water transportation is the most economical method of transportation, and railway next. But there are limits beyond which neither of these methods is practicable. The ocean and certain rivers determine the location of the main base of supply. From this point the successive stages are permanent railroad (either restored roads destroyed by the enemy or newly constructed), portable railroad, automobile trucks or wagons, pack mules or hand-carts, and then the back of the individual soldier.

The organization of a railway corps is imperative in time of war, and at present the plan is to effect out of the many efficient employees now on the civil roads a volunteer organization along military lines, giving rank appropriate to the various duties performed. Some of the most interesting achievements of the Civil War were those of the Railway Construction Corps, in the organization and training of which one of Pennsylvania's sons was a large factor—General Herman Haupt. The bridge built under his direction by E. C. Smeed, over the Potomac Creek, marked a great step forward in the field of railway bridging. That was the bridge which President Lincoln remarked was made of "cornstalks and bean-poles." It was about 400 feet long and 80 feet high, constructed in four tiers—three of trestles and one of crib-work; the time of completion was about nine days. The bridge built under the immediate charge of E. C. Smeed, across the Chattahoochee River, on Sherman's march to the sea, was 780 feet long, 90 feet high, and was constructed in four and one-half days. The bridge across the Rappahannock River, built under the immediate direction of Daniel Stone, was about 600 feet long, 43 feet above the water (which was about 10 feet deep), and was completed in about a week.

In the construction of advance military railroads it is necessary to bear in mind that uniform grade, straight track, and the fine points must be disregarded. The requirement is something which will pass the trains; and the less time expended to accomplish this purpose, the better. The question of cost must not deter the engineer from adopting any necessary means to get the trains over the line. After the road has been made passable, the line can be gone over, lined up, ballasted, and otherwise prepared for the heavier traffic which must follow with the advance of the base of supplies. The Russians did remarkably well in the line of railway construction not only along the

Trans-Siberian route, but also at the front. Their defensive positions at both Lioayang and Mukden were well supplied with rail facilities. At Mukden there were some 50 miles of portable track and about 400 cars, mostly of the flat variety. The power used was two horses, one on each side of the track and outside of it. The portable track consisted of 5-foot sections, 30-inch gage, 25-pound rails, and wooden ties. These portable track lines had a daily capacity of 600 tons of freight each way, though the lines were single-track and the passing points about seven miles apart. This is the equivalent of at least

Fig. 7.—Suspension bridge built in Mindanao, P. I., by Engineers, U. S. A.

400 wagons each way, assuming good roads for travel—of which there were practically none, except in the winter season. The Russians did not get much benefit from their portable road, for the reason that at Mukden their retreat took place before the frost was out of the ground, and at Lioayang the track was removed shortly after the battle began. The Japanese also used portable track extensively. Power was mostly Chinese coolies.

Castramentation, or laying out of permanent camps, is one of the prescribed duties for engineers. Typical layouts are shown in the Field Service Regulations, but it is rarely that these plans can be

adhered to rigidly. Permanent camps would be established for rendezvous in mobilization at home and for winter quarters during campaign. The same general rules hold as for temporary camps, except that generally more resources are available, more time at disposal, and hence more latitude allowable in choosing the site. Communications, water-supply, shelter, disposal of waste, and drainage all require consideration, due regard being given to the defense of the locality.

Fortification is defined as the art of increasing, by engineering devices, the fighting power of troops occupying a position. It may be divided into seacoast, provisional, permanent, and field fortification —including siege works. Seacoast defenses are erected on the theory that the ports of our country must be secure from the attacks of the fleet of the enemy without the aid of our own fleet, which, in substance, means that our fleet must be free to take the offensive; and that, in order successfully to carry an invasion into foreign territory, the enemy must have an open port in the invaded country to serve as a base of supply. One often hears the question asked, "What is the necessity for seacoast fortifications? Are they really of any use?" For reply it is only necessary to recall the great distress of our Atlantic seaboard cities when, during the late unpleasantness with Spain, it was reported that Cervera's fleet was on its way to raid the coast of the United States. It was then appreciated that such cities were without protection, and all that the enemy had to do was come into the harbor and bombard or otherwise as he saw fit—practically dictate any terms. This was due to the failure of the people to insist that their congressmen demand proper defense. At one fort where the author was once stationed it is reported that most of the troops ordered there during the Spanish-American War had never seen a seacoast cannon. In consequence, when the excitement on account of Cervera was at its height, an old schooner put in an appearance, and these troops loaded their old converted rifles with nails and what not and blazed away at it. Their inexperience was a real blessing on this occasion, for they did not come within a quarter of a mile of the vessel. It might be added that there are to-day not enough coast artillery troops to furnish one relief to man the guns, and it can be readily understood that those now available could not stand the constant strain—to which they would necessarily be put— should our ports be threatened.

In this country the art of seacoast fortification has undergone a

development to keep pace with the new inventions of implements of destruction. With the establishment of the United States Military Academy in 1802 the study of this art was started, and by the time of the War of 1812 the principal ports were in such state of defense that there were no attacks made against them from the sea side. The British flotilla finally assembled in the Chesapeake, and, while it did not dare to attack either Washington, Annapolis, or Baltimore from the water side, it was able to land on the banks of the Patuxent and

Fig. 8.—Making fascines (in the cradle) and brush gabions.

proceed by land against our capital. This advance was possible owing to the failure of the government at Washington to appreciate the appeals of General Winder, who urged that strenuous steps be taken for assembling an army to protect against an attack from the rear. It is one of many instances where the advice of the military expert was construed by the civil chief as the ranting of a military alarmist. This incident also teaches the lesson that while the sea-coast fortifications will prevent the harbors from falling into the hands of the enemy, the latter can make a landing at some distance

from the fortification. To prevent his advance it is necessary to have a field army. If this army be repulsed, it must have some defenses behind which to fall back and hold the enemy in check until an army of relief can be sent.

The defenses on which the field army falls back are those constructed around the seaports, and are known as "provisional fortifications." These force the enemy to resort to siege methods, which take time for successful prosecution, and it is during this time that the rescuing army is brought up. Since the enemy has no seaport available to serve as a base of supply for its army, the strength of the latter must be comparatively small, and the defense should thus be able to concentrate sufficient troops to defeat the invaders. If the defense is not able to do this, the besieged garrison is quite certain of defeat. An example of this state of affairs was afforded at Port Arthur during the late war, where the Russians were powerless to send an army of relief. One feature to be noticed is that though the garrison was finally forced to surrender, it neutralized, for about six months, about 40 per cent. of the entire Japanese force in the peninsula. Another feature to be noticed is that even though the seacoast defenses of Port Arthur were known to be in a state of efficiency far from satisfactory, the Japanese did not seriously attempt to attack them from the sea. Still another lesson to be learned is that by the failure to fortify Dalny, the Russians afforded their enemy an excellent port for a base of supply not only for the operations against Port Arthur, but against the main Russian army in Manchuria.

Unfortunately the plans of our national fortifications are considered confidential, and the author is unable to present any very satisfactory views of them. The features are not essentially different from many civil structures, except that the masses of concrete are quite large, and as a result considerable difficulty has been experienced in keeping the magazines dry, the low temperature of the concrete in summer favoring condensation. This objection has been almost entirely eliminated by requiring the rooms to be opened at such times as are favorable for heating, but when the relative humidity is low.

Seacoast fortifications were first constructed of earth, then of brick and masonry. After the Civil War, and largely as a result of the experience gained during that period, but principally owing to the invention of the ironclad, and later of the explosive shell, the type of construction was changed to concrete and sand. The invention of the disappearing carriage has greatly increased the advantage, always

conceded, of batteries on land over those afloat. Where there are channels to be protected, the rifle defense is materially assisted by submarine mining. The submarine mining defense, once in the charge of the engineers, is now in the hands of the coast artillery, although the development of the system is due to General H. L. Abbot, Corps of Engineers. His system has been changed in some of the details, but the general plans remain the same. General Abbot will also be remembered as having made, in conjunction with General Humphreys, the valuable experiments on the Mississippi with reference to the flow of water in open channels.

FIG. 9.—Sand-bag, post, gabion, sand-bag, sod and board revetments (from the right).

Provisional fortifications, to which reference has been previously made, is the term applied to the land defense of our ports, the plans for which are made in time of peace, but the execution of which is begun only after the declaration of war—and then only if considered necessary. In our own country little has been done along this line until quite recently. Foreign nations which have centers of great strategic importance, especially those along their borders, are encircled by what are known as permanent fortifications. These are made very strong and have within them all the facilities and supplies

for holding out against a siege for months and even years. The cost of permanent fortifications and the fact that we have practically no frontier to defend have eliminated even the thought of this type in our national system of defense. The resources of this country are so great that there is not so much need of collecting supplies and munition at strategic points and then fortifying such points by extensive works. This nation is largely self-sustaining; it can, if necessity demands, exist without foreign products. The bread-basket is in the central area toward which the defense would naturally be forced back by the invaders. This proceeding would not be very comforting for those who live on the coasts; but as far as actual necessities go the defending army could continue to exist—or subsist, rather, for almost all the powder and arms are manufactured on the coasts, and before long it would be out of ammunition.

An invasion against the Atlantic coast could be more advantageously handled than one against the Pacific coast, for the reason that the center of gravity of the regular and organized militia troops is well toward the eastern part of the country. It is not believed that many who have studied the problem will contend that the occupation of the Atlantic seaboard by any one of several of the European powers is an impossibility; nor will many deny that it would be impossible for the United States to make a great impression against any such invasion until after a very long period of preparation, and, consequently, after great loss in ground, money, and lives. As for the Pacific coast, it is best not to make any statements, for the contrast of our impossibilities with the possibilities of at least one other nation is not pleasant to contemplate. In this connection, those who may be interested can refer to the book by Homer Lea, "The Valor of Ignorance." If every thinking citizen would read that book, there would probably be some favorable legislation with a view to placing the national defenses on a basis which would simply represent good insurance. Military men are generally considered alarmists, but they have seen in the past what a lack of preparation has meant. "Conservatism in time of peace and prodigality in time of war" seems to be the national motto. This prodigality extends not only to money and property, but to the lives of the citizens. Who does not remember the harvest which typhoid fever reaped at the volunteer camps in 1898? In addition to the actual loss of life, there is to-day a pension roll which stands as an example of the lack of training men to care for themselves. If any one thinks that placing a musket on

a man's shoulder makes a soldier of him, let him contrast the loss of life of the regular and that of the volunteer who has had no time to learn how to care for himself. No one prays more for peace than does the military man, for he does not want to be offered up a living sacrifice, nor does he want to see the men who have the stamina to volunteer slain by germs before they get a chance to even see the enemy.

It may seem incredible, but to equip with field artillery a force of sufficient size to resist an invasion of the Pacific coast would take sixteen years. There is talk of aëroplanes completely revolutionizing military methods, that they will be able to completely annihilate

Fig. 10.—Japanese scaling ladder; for scaling walls or obstacles.

everything, which reminds one of the story that is told of the inventor of the bullet-proof jacket who called on President Lincoln for the purpose of getting one regiment equipped with them; he thought that that would be sufficient to completely wipe out all the Confederate troops. The President seemed to be favorably impressed, and had the inventor try on the jacket. "Now," he said, "you stand over there by the door, and James, go get my pistol; I want to try that." Upon the return of the servant, the inventor was not to be found. Aëroplane men had better buy some bullet-proof jackets, for it is safe to prophesy that it will not take long for some Yankee to devise a method to bring them down the same as

other birds. The aëroplane will have its use, and it marks a great advance, but the time is far distant when men will cease to have misunderstandings, and when, as a result, they will not go out to look for one another with guns.

In the late Spanish war vessels were bought for exorbitant prices and afterward sold for a song. On the transports which sailed to Cuba and to the Philippines some of the sights were distressing. Men were forced to live where human beings could hardly exist, as the vessels were not at all adapted to the purpose of troop transportation. Everything was piled on in helter-skelter fashion—the equipment needed first was almost sure to be in the bottom of the hold. This does not say that every effort to make the best of things was not made. It was simply a case of trying to move a mountain with a crowbar. Every one worked like a beaver, but it was trying to do the impossible. Our navy is helpless to-day because it has practically no American bottoms in which to carry coal. There are very few American ships suitable for transporting our troops; just about enough to carry an army of proper size to be annihilated in case it attempted to land anywhere in the enemy's vicinity.

As far as equipment is concerned, the engineers are more fortunate than certain other branches of the army, for there are always tools of some sort to be had in the open markets. Pontoons and many other parts of the equipment cannot be picked up, nor made in short order. In order to get all the tools into the limited transportation available, some of them must be made special, and the capacity of the manufacturers of these articles is limited.

Field fortification, as its name indicates, applies to the strengthening of temporary or field positions by engineering devices. One feature about this subject, so far as learning it is concerned, is that while it is difficult to arouse interest in digging trenches in time of peace, it requires very little exhortation in time of war to get plenty of practical work. After a few skirmishes, men throw away their knapsacks before they do their spades.

Field fortification may be divided into hasty intrenchments, deliberate intrenchments, and siege works. Hasty intrenchments are those thrown up in the immediate presence of the enemy. Deliberate intrenchments are those constructed in anticipation of future attacks of the enemy, but at some distance from him and when there is plenty of time for the work. Siege works embrace those methods used in the attack of places so fortified as to be impossible of capture

before a breach has been made in the line of the defense. In an engineering sense, the Engineer Field Manual divides the subject into classes according to the various devices employed. These are: (1) those producing an unobstructed field of fire; (2) those giving protection from the fire of the enemy; (3) obstacles to the advance of the enemy; (4) obstructions to the enemy's communications. To secure a clear field of fire it is necessary to cut trees, destroy buildings, and fill in the low places in the foreground so as to get a sweeping fire at the enemy as he advances. Trees and vegetation when cut may oftentimes be made of great assistance to the defense by forming

FIG. 11.—First Japanese locomotive into Port Arthur; also chevaux-de-frise standing alongside the track.

obstacles. For instance, the Japanese during the last war would cut the kowliang a short distance above the ground, felling the stalks toward the enemy. It is said that this formed an effectual obstacle. Trees or brush should be felled toward the enemy and have the branches pointed. It was the slashing of trees which delayed General Smith in his attack on Petersburg (just as General Grant had succeeded in passing the James), the capture of which would have made the early capture of Richmond an almost foregone conclusion. It was as well that he was delayed, for the result was the eventual cornering of General Lee, while had Petersburg been taken the

latter would probably have retreated southward and effected a junction with Johnston and thus have prolonged a hopeless war.

The tendency to-day in intrenching is to make the trench as narrow as practicable; this is on account of the high angle of fall of shrapnel fired by the modern field artillery. The narrow type of trench was first extensively used by the Boers in South Africa. The Boers would also carry the earth some distance to the rear, to avoid giving any indication of the location of the trench. The development in recent years has been largely in these two directions—narrowing the trenches and concealing them. Concealment has, since the Boer War, been given the consideration which it properly merits. Formerly the officer or enlisted man who showed any desire to take advantage of cover was looked upon as a coward. It was learned by the British, in fighting the Boers, that to stand up in a battle was nothing more nor less than suicide. Exposure to fire when it can be avoided is permissible only when it is necessary to set an example to the troops. To afford a vertical face against which the firer can stand and to economize space requires that the earth be made to stand at a steeper slope than the natural. These objects are accomplished by making revetments. These may be of sod, sand-bag, board, post, gabion of brush and strap-iron, fascine, and hurdle types. The nature of the trench will depend largely on the nature of the soil and the location of the line. Thus the protection along a rocky footing would necessarily consist of material transported from a distance, and would therefore be of earth or sand in bags. The development of the trench is gradual; at first it consists of the few shovelfuls of earth which the skirmisher throws up as he stops in his rushes forward. This is gradually enlarged, and finally the profile is such as will resist siege guns, should necessity require. The thickness of earth parapet to resist these guns is about 20 feet.

After the trenches have been constructed and concealed, there yet remains one very important feature to be installed—obstacles. During the preliminary attack by the enemy, which usually consists of an artillery bombardment, the defenders are under the protection of bomb-proofs, generally located at some distance back of the parapet. The attacking artillery will cease firing when its infantry has gained a position about 200 yards from the defense's trenches. The obstacles in front of the trenches must therefore be nearer than that to the trenches, for otherwise the attacking infantry could remove them while under the protecting fire of its artillery. The defenders must

have time to man the parapet after the artillery ceases firing and before the infantry reaches the obstacles; this, coupled with the consideration that the obstacles must be far enough away to prevent the throwing of hand grenades into the trenches before the enemy gets to the obstacle, determines the distance to be about 150 yards in front of the trenches.

The best form of obstacle against infantry is believed to be the high wire entanglement. The Russians used trous de loup, or military pits, extensively. The Filipinos used much the same type along the roads or paths. They dug pits, covered them with light bamboo strips and straw, and these with earth, and then placed sharpened stakes in the bottom and sides, sometimes poisoning the tips also. The troops finally insured the discontinuance of the practice by impressing native guides, captured in the neighborhoods, who were compelled to lead the columns.

Abattis is an obstacle formed by placing felled trees close together in a row along the front, branches pointed and toward the enemy. It can be destroyed by fire of artillery, and for this reason it is customary to protect it by a very low parapet. Slashings differ from abattis in that in this form of an obstacle the trees are left in position where felled. This forms an obstruction, but not necessarily a continuous one, unless the trees are very close together. It is of particular efficacy in obstructing roads through forests. It was the slashings made by McClellan to protect his right flank which delayed Stonewall Jackson from striking Porter at the beginning of the Seven Days' Battle. A simple engineering work thus saved the Federal army from almost certain defeat.

There are several forms of obstacles used against cavalry. Chevaux de frise and low wire entanglement are employed principally. In the latter the stakes to which the wire is fastened are only some 18 inches above the ground. The chevaux de frise consist of a line of crossed stakes or iron rods sharpened at the ends, either passed through a beam or otherwise fastened at the point of crossing. In side elevation it resembles a saw-buck. Several modifications of this idea were used by the Russian and the Japanese as a portable obstacle against cavalry. One feature of the Russo-Japanese War was the paucity of cavalry operations; however, an attack of cavalry, mounted, against infantry intrenched, where such obstacles would be used, is believed to be past history.

The establishing of communications between the various portions

of the defenders' lines is properly one of the functions of the engineers. Provision is made in the trenches themselves, after they have reached a certain point, for men to pass along in rear of the firer, in order that the portions of the line hard pressed may be reinforced. In the rear of the line of field works and trenches are held the supports, in groups. Some distance, in the rear of these still larger groups are placed, called the reserve. The sub-depots are also along the line of reserves. In the rear of these is the advance supply depot, and farther yet to the rear is the advance base. It is seen that the whole formation is like a fan. The Russians at Mukden constructed, in connection with the defenses of the Sha River, a typical system of communications in the rear of a position. The main road along the line of reserves and supply depots—generally about four miles in the rear of the trenches—is built as wide as 80 or 100 feet, depending on the size of the force to be supplied. Of course, this width is reduced toward the flank portions of the line. The portable railroad is pushed as far to the front as practicable, the wagon roads beginning where the limit of portable railroad is reached.

The work of construction of the ordinary field works is done by the troops of the line under the supervision of engineer officers and enlisted assistants. The construction of the more important works may be done entirely by the engineer troops.

The subject of the obstruction of the enemy's lines of communications has already been referred to in the delaying of Stonewall Jackson. The obstructions placed across his path marked the beginning of a week of his life which brought to him the title, for the time, "Jackson of the Chickahominy." It was exactly the opposite of his general reputation of being at some point which it was impossible for him to reach, on account of distance to be covered. Those who gave him that title failed to consider that his wonderful marches were not through slashings.

The necessity for resort to siege methods has been referred to in considering the operations of an invading army against provisional fortifications in rear of the seacoast fortifications. It was at Acre that the great Napoleon met his first defeat of purpose. After having maintained a siege for sixty-two days, in which time there were many assaults and sorties, his dream of conquering the orient was shattered and he was compelled to withdraw. Being somewhat modern in his ideas, he was able, by a well managed press bureau, to use this very defeat to herald his military prowess and thus to aid in his subsequent

elevation. The siege of Syracuse under Marcellus, in 212 B. C., was withstood for eight months, and would probably have continued indefinitely by the clever devices of Archimedes, had not the Sicilians fallen victims to enticement. The sieges of ancient days meant much to the defenders, for it was death or slavery to the losers. However, they did not, as to-day, mean a vigorous prosecution of attack, but were more of the character of a blockade. The siege of Troy in the twelfth century B. C. was of eight years' duration; the siege of Ithome in Messinia, by the Spartans in the eighth century B. C., was likewise a drawn-out affair—eight years. The siege of Ira, in the succeeding century, took up eleven years.

A great advance was made by the Greeks in the fifth century, when they formed their lines of circumvallation, prepared covered ways and approaches toward the walls, and invented the process of mining under the walls. At this time explosive was unknown, but their methods were the same practically; they would run a shaft under the walls, make a mine chamber, and build hot fires in them. The heat would cause the earth to crumble, and finally cause a breach in the wall, toward which the assault could be made. There was a great improvement in the art of fortification and siege methods during the French Revolution; by this date the captured garrison were considered prisoners of war, which feature tended to lessen the efforts, formerly so imperative, to endure the siege.

The modern method of conducting a siege is to establish the line of investment, place the artillery in position, usually about 3000 yards from the defenders' lines, and then, the points of attack having been determined upon, open the first trench, generally parallel to the defenders' line of works. This trench is called the first parallel; it is usually about 1200 yards from the enemy. Zigzag lines, called approaches, are then run toward the front, being given directions such that they lie outside of the tangent to the enemy's most advanced works which bear upon the approaches, the excavated earth being thrown on the side toward the enemy only; this is called a single sap. When the approaches have been pushed so far to the front as to be beyond the limit of effective protection by troops posted in the first parallel, it is necessary to open another parallel; this will be about 600 yards in front of the first parallel. This parallel completed, approaches are again started to the front. At this stage the fire of the enemy may be so plunging as to require protection on both sides and in front, when what is known as the double sap is started; this is

similar to the single sap, but it is wider, two men working at the head; the earth is thrown on both sides and sand-bags are placed in front and pushed forward as the head of the sap progresses. Farther along it may be necessary to completely cover the trench overhead.

When the heads of the saps have reached a point from which it is believed the assault can be made, another parallel is opened. It will be necessary to resort to mining operations soon after this; these are begun either by first sinking a shaft and breaking out the galleries or, if the ground has the proper slope, by beginning the galleries direct. The galleries having been driven under the fort, the mine chamber is formed and explosive placed. In all the mining operations it is necessary that the work be carried on as quietly as possible, for the enemy will undoubtedly countermine. The mine having been prepared, the troops are formed for the assault, and at the prearranged time the artillery bombards, the mine is exploded, and the infantry immediately advances toward the breach so as to get the full benefit of the demoralization of the defenders.

It should be a matter of pride to Pennsylvania to know that the greatest mining operation of the Civil War, at Petersburg in front of Richmond, was carried out by Lieutenant-Colonel Pleasants with his 48th Pennsylvania Regiment, composed of practical miners. The success of the attack was prevented by the cowardice of Generals Ferrero and Ledlie, the latter of whom had been chosen by lot to lead the assault; they were back in the bomb-proofs. It might be here remarked that the country must depend largely on Pennsylvania for the men to undertake future operations in the line of siege work.

The *improvement of rivers and harbors* is one of the duties especially assigned to the Corps of Engineers. The improvements of the lakes and harbors consist of dredging, as at Portland, Maine, New York, and Philadelphia; construction of breakwaters, such as the Delaware and San Pedro; jetty work, as at Charleston and at the mouths of the Columbia and the Mississippi, and canal locks as at the Sault Sainte Marie and Detroit.

River improvement consists of dredging, as in the Mississippi, Missouri, and other rivers where directed by Congress; the regularization of alluvial streams by dikes and jetties, as on the Missouri and the Mississippi; the revetment of banks on the two last mentioned streams, and what is known as slack water improvement by locks and dams, such as on the Ohio and its tributaries.

From what has already been said regarding seacoast defenses, it is

easy to appreciate that there is an intimate connection between that work and the improvement of the harbors which they protect. It could not be said that it is absolutely necessary, in order to draw plans for the defense of a port, that the improvement of its harbor be executed by the same engineer. However, for several reasons, it is certainly more convenient that it should be so.

First, any alteration of the roadstead or of the channel, which might be taken advantage of by an enemy, is no sooner planned by the engineer in charge than the necessary steps are taken for the defense.

Second, since this country will never establish permanent fortifications for the defense of our seaports from the land side, and, in consequence, all that will exist in the way of preparation for defense will be the plans of the provisional fortifications, the advantage of having an engineer officer, usually of considerable experience, in charge of operations in the vicinity of the seaports, so as to familiarize himself with the local resources, topography, labor supply, and conditions in general, and thus be prepared in time of war to commence the vigorous prosecution of the defenses, can well be understood to be a great asset. Practically every city on the seaboard, which has any value as a port, has a district engineer office or a branch of such an office. The plans for the defense of the locality are familiar to the officer in charge, and he usually has a sufficiently large working force under him to organize the necessary parties for constructing the works upon the outbreak of hostilities.

The third, and probably the greatest reason for putting the river and harbor work in charge of the army engineers is that they must have something to do to keep them from rusting out in time of peace. It is believed, from what has been said above, that it can be appreciated that the exercise of engineering ability in time of war requires that the officer be practised in his art and that he be thoroughly alive; that he must have back of him achievements to give him that confidence which nothing but past successes in dealing with men and with engineering problems can give him. The art of fortification and the other varied duties which, judging from the past, are sure to come to the engineer officer in time of war involve many branches of engineering, such as water-supply, waste disposal, road and bridge construction, power transmission, mining, and various branches of municipal engineering. During the late war with Spain it was necessary to build a steel bridge, reconstruct many other bridges, restore and

operate the Manila and Dagupan Railroad in Luzon and the railroad from Siboney to Santiago in Cuba, plan the water system of the city of Manila, clean the city of Havana in Cuba, and perform many other tasks in civil engineering. The duties of the district engineer officer give him some experience in almost all branches of engineering; what he does not have an opportunity to practise, he may observe in the activities in the cities where he may be stationed. There could be no more effective method of killing ability in the Corps of Engineers than to restrict its duties to those with troops serving at the ordinary military post. It was the civil activity of the famous generals of the Civil War, many of whom were formerly engineer officers, which made them successful in handling men.

It might be claimed that all the engineering work during the war could be done by civil engineers commissioned for the war. However, the art of fortification requires special training, and there are many other military specialties in which the civil engineer has not the time to become an expert while gaining a livelihood in time of peace. Again, the engineering problems which arise during the war are not ordinarily such as may be abandoned at the cessation of hostilities, and the salary of an officer of the army is not such as to attract many engineers in civil practice, who would be able to make a success with the military tasks. Such men would probably feel that in justice to themselves they could not remain away from their private practice at a sacrifice, when the war was over. With the engineer officer it is different; he has adopted the army as a profession, has been brought up in it from his boyhood, and while the salary is not large compared with that paid for like responsibility in civil life, there is the assurance of a secure position practising a profession which appeals to the patriotic instinct. The education at West Point develops the idea in the future officer that there is no service more noble than that of a defender of his country. The Academy's motto is "Duty, Honor, Country."

Several attempts have been made to remove the river and harbor work from the charge of the Corps of Engineers, but without success; it was tried during the last session of Congress without avail. A study of the reasons for the unwillingness of Congress to do this seems to indicate a conviction on the part of congressmen that the Corps of Engineers is a national product, adopted and reared at the National Academy at the national expense, and that the country has a right to use whatever of talents the corps may have. Another and

probably the principal reason, as stated by one of the leading engineering periodicals, is that the Corps of Engineers is a strictly non-partisan body, entirely free from local prejudices, composed of men who are fearless, owing to the security of their position, and who therefore ought to be able to render an unbiased opinion. While this opinion may not be very satisfying to the congressman himself, he knows his colleagues will be accorded the same treatment.

There are to-day many branches of civil engineering in the government service, and it would appear to be only ordinary business sagacity for the government to retain one branch of the national public works for its protégés. The river and harbor work is but a small part of the total engineering done by the government. There are many openings for engineers in the various branches of the government service, among which may be mentioned the Reclamation Service, the Geological Survey, the Coast and Geodetic Survey, public building construction under the Treasury Department, and others under the Agricultural Department.

The civil engineer does not need to enter the government employ to render the country more than his share of service, for to-day it is he who is coming to the front as the logical director of public affairs. In the practice of his private business he is making the earth produce results from her latent resources. The cry of late has been, "Give us a business man for mayor, or for governor"; the author would amend this by saying, "Give us an engineer for our mayor or our governor." In fact, the governing of our cities especially, and of our states very largely, consists of the solution of civil engineering problems. As the people consider the proposition more and more, it will be found that they will insist on having men as public officials who know how to execute public improvements economically, and who will do it honestly.

In time of peace the engineer is a public benefactor; in time of war he is his country's reliance. The successful handlers of men in time of peace will be found leaders of men in time of war. There is every reason for coöperation between the engineer in civil life and the military engineer; the country needs the engineer in time of war, for modern war is getting to be more and more an engineering proposition. Knowledge of what materials, forces, and men can do, and practical experience in using them, are what win the day. The engineer is the man who, more than any other, should be well qualified.

SMOKE PREVENTION.

A Discussion by Members and Visitors.

October 1, 1910.

D. T. Randall (Visitor).—The abatement of smoke is largely an engineering question, but nearly every city that attempts it, makes the mistake of thinking that the mere passing of an ordinance will clear it of smoke, which it never does. Washington, D. C., is the only city in the United States where an ordinance is effective.

The experience of nearly all large cities that have a real smoke problem has been that, in the first place, the ordinance has been contested by the people who were brought into court, and the whole thing has been found ineffective. The only way to attack the problem is from the engineering standpoint. It is all right to have a law, but the law alone cannot stop the smoke.

The character of the coal burned is one of the very important questions in connection with the abatement of smoke. This locality is fortunate in having large quantities of very good coal; there is considerable anthracite which is very low in volatile matter. It has been found that the volatile matter in different kinds of coal does not vary directly with the quantity of smoke produced; that is, although different coals apparently have the same percentage of volatile matter, the smoke produced will be more with some and less with others. This is due to the character of the hydrocarbon gases and the amount of tar contained in the coal. A coal having 16 per cent. of volatile matter is usually more easily burned without smoke than one having 20 per cent. or 22 per cent.; then there is an increasing difficulty in burning the coals containing 25 per cent. or more volatile matter. The amount of ash in a coal does not have any great influence on the amount of smoke, but it has some. The ash, which fuses at a low temperature, remains on the grate bars of a furnace, and, of course, makes it more difficult to operate, retards the flow of air through the fire, and tends to make more smoke.

The item of moisture in coal is not of much importance in this territory, but the higher the percentage of moisture contained, the more smoke will be given off from the same coal. For instance,

if a good grade of coal is exposed to a heavy rain, it gets quite wet, and is more difficult to burn without smoke, owing to the fact that it packs when put on the fire, shuts out the air, and cools down the fuel bed at that point. If a coal cakes and is charged into the furnace in large quantities it may form a compact mass and shut out the air. In barring up the fire, there is a good deal more smoke produced than when it is charged into the furnace, which can be obviated by shoveling in smaller quantities. It will be necessary to disturb the fuel bed only when ash or clinker has accumulated to such an extent as to prevent the air from passing through all parts of the fuel bed.

If large sizes of coal are used, the air is usually admitted quite uniformly through the fuel bed. If there is too much air, the efficiency obtained is not as high as when the smaller coals are used, but the larger coals give less smoke.

The quantity of fuel that has to be burned in different furnaces is a great item. With a given size combustion chamber one can usually burn a limited quantity of fuel without smoke, but if its capacity is exceeded, the tendency is to smoke more and more, as, for example, a locomotive, when it is crowded to four or five times the capacity of ordinary boilers. Under such circumstances one cannot expect to burn all the volatile gases, and they will appear at the top of the stack as smoke.

In burning coke or anthracite coal, the fuel is nearly all consumed on the grate or above the grate; but where bituminous coal is burned, it requires some time for the liberated gas and air to mix and ignite. A larger combustion chamber is required for a higher volatile coal. In other words, there are two kinds of fuel: coke on the grate, and a gas which burns above the fire in the combustion chamber. If the combustion is not completed in the chamber, there is a loss of gases, and particles of carbon are deposited on the boiler-tubes. This carbon usually comes from the breaking-down of the heavy hydrocarbons.

The draft is another important item in preventing smoke. Many plants have not draft enough to burn coal at the higher rates. Firemen who have to do everything possible to get air through the fires, will produce smoke when the capacity of the furnace is crowded. Every plant should have more draft than is necessary to burn the coal under ordinary conditions, and then that draft should be made effective only when the load is very heavy.

The character of the load is important, because, if a steady condi-

tion can be established in the furnace, a certain thickness of fire, a certain draft, and maintained straight through, it is fairly easy to burn ordinary coals without smoke; but if the load is variable, and it is necessary to close and open the damper frequently, then the conditions make it almost impossible to prevent smoke, because at one time there is an excess of air—when the damper is wide open—and again there will not be enough air passing through the fire when the damper is closed. The plants with varying loads present the most difficult problems. They are almost as difficult as the ones having a heavy overload.

The fireman has a great deal to do with the smoke problem. There is one plant that is being operated exceptionally well, and it does not make smoke enough to be objectionable. At the same time, if the fireman were to allow the fire to get one, two, or three inches thicker than is allowed, the plant would become smoky.

In order to discuss furnaces, it may be said that one of the most simple types of furnace is the iron-inclosed furnace, like that of a locomotive, or a house-heating boiler, or some of the types where the water surface surrounds the fire and usually the combustion space. Such furnaces are usually designed for burning anthracite coal or coke, which they will burn quite efficiently. They do not burn bituminous coal as completely as other furnaces. The common house-heating boilers, used for heating houses in this city, give about 60 per cent. efficiency from coke or anthracite coal, but with bituminous coal the efficiency will drop quite regularly, according to the increase of volatile matter in the coal. There is a drop in efficiency of about 12 per cent. from the anthracite, and down through the high volatile coals such as come from the western fields. In a good hand-fired plant with a well designed furnace, the drop in efficiency would not be more than about half as much; it would probably be about 5 or 6 per cent.

The next type of furnace is the water-tube boiler, where the side walls are brick and where the water-tubes are exposed to the gases immediately after they leave the fuel bed, perhaps not more than three or four feet above the fuel bed. The difficulty in burning coals in these boilers is that, if one side is fired a little thicker than the other, the air will tend to go through the side which is fired thinnest, the gases will pass up almost straight through the fuel bed into the boiler, and while there may be some air on one side and gas on the other, there is not time for the air and gas to mix and burn before reaching

the boiler-tubes. This sometimes causes a loss of unburned gases as high as 5 or 6 per cent. of the value of the coal—a result often of poor firing.

Then there are the furnaces with the water surfaces of the boiler forming the top of the combustion chamber, and side walls of brick, something like the Heine boiler. These boilers have a longer passage for the gases, which do not go directly up from the fire, but flow in a horizontal direction, and after passing over the bridge wall and over other obstructions in the furnace, mix, and then have a space of about 10 feet to burn in. In boilers of this type it is easier to prevent smoke than where the gas enters directly above the grates.

Furnaces of the last type are modified by brick arches, piers, etc., to assist in mixing the gases. There may be a set of piers which cause the gases to travel back and forth, and many such furnaces are burning bituminous coal, with good results.

Another common method of preventing smoke is by the use of the steam jet. The use of steam jets is not economical, but it will stop smoke. Steam jets are applied to nearly all of the classes of furnaces just mentioned.

The automatic stoker is usually considered the best method of abating smoke, and it can be applied to boilers of almost any type. The stokers work best where there is a large combustion chamber for the gases to burn in before reaching the boiler surface. The mere addition of two or three feet to the combustion chamber of a boiler has oftentimes changed a smoky plant to a practically smokeless one. In the west a certain type of chain grate stoker would oftentimes make some plants entirely smokeless, and other plants not. In the latter cases the difficulty was accounted for by not having a long enough space for the gases to burn in, and by moving the stoker out two or three feet a combustion chamber was provided, necessary for the ready and smokeless combustion of the coal.

Some automatic stokers are so well designed with respect to the setting for a particular boiler that it is very difficult to make it smoke.

The statements may be summarized as follows:

Any type of boiler may be operated with but little smoke with low volatile coals, and in some cases with other coals, provided the rate of combustion is very low.

Hand-fired furnaces with brick arches are more easily operated without smoke than the plain furnaces.

Almost any hand-fired furnace may be operated by means of steam jets so as to produce but little smoke.

While these results may be obtained by a skilled fireman, such plants cannot be depended upon to be smokeless at all times. Experience has shown that a change of fuel or a change of firemen may cause plants to become smoky, owing to a difference in methods or rate of firing.

Stokers without suitable combustion chambers or when improperly operated may be expected to produce a great deal of smoke.

Experience has demonstrated that the best stokers properly installed are superior to hand-fired furnaces for economy and smokeless operation.

At one time it was my privilege to visit nearly all of the larger cities that have a smoke problem to deal with, to meet the committees who were directly interested in the work, and in some cases to discuss the question with them. Cities that have tried to prevent smoke by merely passing an ordinance have not been successful. The cities that have been longest in the movement against smoke find they must treat the smoke problem like any other problem of public interest. If a law is passed to control building construction, inspectors must see that it is carried out; if plumbing is to be regulated, the requirements are first of all approved by some competent person, before they are incorporated in an ordinance, and so on. One cannot expect every manufacturer to immediately improve his plant and stop the smoke. It is strictly an engineering problem. It requires remodeling of plants in all cases to burn the coals that are available. It is natural for business men and manufacturers to burn the coal which makes the cheapest fuel for them, and they should therefore have their furnaces adapted for such coal. Sometimes a man is in a rented building, and therefore does not want to change the furnace which is in use.

It is not an easy thing to tell a man how to stop smoke in his plant. It is not a solution of the smoke problem to get a few competitive bids on equipment for the boiler-house, even though the stoker manufacturer may guarantee to stop the smoke, which, in many cases, is not accomplished, mainly because the stoker is not used properly, or was not properly installed for the load and the particular fuel used. Some cities which have taken up this question very carefully have found the need of an engineering organization to solve the smoke problem, one that can obtain records and data from plants, and compile engineering

information pertaining to and bearing on the smoke question. Such an organization advises owners of plants regarding changes either in the equipment or the methods of firing which will reduce the quantity of smoke. The most important thing is to have supervision of all new boiler plants that are put in and of the remodeling of all old ones, so that it will be done along the lines of smokeless furnaces. One of the most hopeful things is to find in some of the cities that nearly all the new plants—especially the large plants—are being installed, in the best way known at the present time to prevent smoke, and in nearly all of the larger cities it will be found that the most recent plants are pretty successful in the abatement of smoke; and as it is only a matter of time when the old plants will be remodeled, or rebuilt entirely, they too can be brought into that class. The discussion of the smoke problem for a city like Philadelphia should, in part, lie along the line of the best methods of organizing a smoke commission. It does not pay, in trying to stop smoke, to antagonize manufacturing interests, and it is not necessary to do it. Manufacturers and other business men are usually interested in the welfare of the city, and they will take steps to do things, if brought before them in the proper way. Occasionally one may find men who will not, but such are exceptions.

Two cities are working along lines suggested. One, Cleveland, Ohio, has perhaps been working on such lines for the longest time. It is not a smokeless city, but it has a number of plants that are quite smokeless, and they are being added to all the time. At the time the smoke abatement idea was about to be put into practice, Professor Benjamin, of the Case School of Applied Science, was prevailed upon to take the position of smoke inspector in Cleveland. He is an engineer who has given a great deal of attention to smokeless combustion, and he started out with the idea of getting as many new plants as possible into line, and whenever a man changed an old plant, he would have him change it along the right lines. There is very little friction in Cleveland between the city officials and the business interests, and many of the large manufacturing interests are putting in plants that are automatic.

The city of Chicago has had a serious time with smoke problems. Many of the coals there are high in volatile matter. A good many things have been tried; three or four serious trials at preventing smoke have been made in the last twenty years, and not one was successful until the last one. Finally the entire thing was taken

out of politics, and the mayor appointed a commission of the leading business men of the city. If a man is called before the smoke inspector, it does him no good to appeal to his alderman, or any one else. Not many cases are being brought into the courts; the work is along the lines of getting people to put in plants in accordance with the best practice for abating smoke. Some plants are hand-fired, some stoker-fired, but there are a great many more smokeless power plants than ever before.

Joseph S. Neff, M.D. (Visitor).—I quite agree with Mr. Randall that the "smoke nuisance" is an engineering problem. From this standpoint I am not qualified to open the discussion, and must, therefore, confine my remarks to those phases of the subject concerning which I have some knowledge and practical experience.

In this city I hardly feel that our legislation on the subject is sufficient to enable the authorities to abate the nuisance. We work under an ordinance, dated December 9, 1904, which is worded so that it is difficult to procure convictions thereunder. The section determining the degree of darkness of smoke emitted, by a color scale of measurement, admits of expert testimony on both sides of the question. This, I regret to say, can be obtained on short notice.

Another section of the ordinance forbids the emission or escape of smoke, of a certain character, from any locomotive or river steamcraft. This section also prohibits the emission of smoke from stacks, etc., and is followed by a proviso: "That none of the provisions of this ordinance shall apply to a locomotive or locomotives or river steam-craft in continuous transit through or across the city, or while entering or departing therefrom." As a great deal of the smoke nuisance is produced by locomotives, and, as they are always found entering or departing from the city, the ordinance is useless.

Therefore the problem demands a steady and progressive campaign of education, to the end that pressure of public opinion will lead to the enactment of more efficient legislation. By education manufacturers can be brought to realize that the heavy clouds of black smoke pouring from their factory and workshop stacks are virtually the useless and wasteful burning up of so many dollars in increased coal consumption. Public sentiment, properly directed, and supported by proper legislation, can greatly aid in the eradication of the evil.

It has been said the health authorities have power to prevent existing conditions. This is not true. The only method they could employ is ordering the abatement of any particular smoke nuisance

on the ground that such nuisance is prejudicial to public health. This position could not be successfully maintained in court, however, as smoke does not cause consumption, influenza, or, in fact, any particular disease.

As evidence of this the vital statistics of the United States and Europe in towns where the smoke nuisance is most marked do not show an increased mortality from pulmonary diseases. In Washington, New York, and Los Angeles—so-called clean cities—we find per 100,000 of population a higher mortality from consumption than in moderately dirty cities, such as Philadelphia, Buffalo, Detroit, Milwaukee, and Boston.

In the latter city, according to the United States Census Report for 1908, the mortality from consumption was 146 cases per 100,000, while in such cities as Pittsburg, Cincinnati, Chicago, and Youngstown, where the smoke nuisance is more marked, the mortality was 149 per 100,000, or only three higher than moderately dirty Boston.

Smoke does have a decidedly irritating influence, however, especially on the mucous membranes of the upper air-passages. It reduces the vitality of the individual, thus making him more susceptible to disease. It undoubtedly cultivates a more fertile soil for the development of pathogenic germs than would be found on normal mucous membranes. It also has a deleterious effect by reason of aggravating the condition of those parts already diseased.

During my first year as Director of the Department of Health and Charities I was optimistic, and undertook a solution of the problem from a health standpoint. To ascertain if I would have the backing of the medical profession in a crusade against the smoke evil, I communicated with a hundred of the more prominent physicians of the city. The majority of these, particularly the specialists on the eye, ear, nose, throat, and lungs, felt that the position of the department could be maintained from a health standpoint. A minority believed the smoke could be construed as a detriment to public health. The large majority, however, felt that notwithstanding the injurious effect of smoke on delicate mucous membranes, the department's health position could not be maintained in court. Again, a small minority, among whom were several of the most prominent sanitarians in Philadelphia, declared that the evil must be handled as a "common nuisance," and not as a "health nuisance." Among the correspondents were several, one a tuberculosis expert of international

reputation, who contended that smoke was in nowise prejudicial to public health.

About two years ago I attempted to inaugurate a movement for some permanent relief from the smoke nuisance, and solicited the aid of the medical profession. Notwithstanding earnest efforts on the part of such able men as Drs. S. Weir Mitchell, J. Madison Taylor, Henry Leffmann, and others, the movement failed. Largely through the efforts of the two last named gentlemen, public meetings were held by the County Medical Society. These meetings were largely advertised and able papers were read dealing with the subject. With all this, but little interest was created.

Last spring the College of Physicians and Surgeons passed a resolution presented by Dr. Mitchell authorizing the president to appoint a committee to investigate the subject. After several months' effort the president reported that he had failed to find a member of the college, of standing, sufficiently interested to undertake the chairmanship of this committee, and up to the present time I believe the committee has not been appointed.

For these reasons, with present legislation, I believe progress will be made only through public education, and in the organization of a movement in the strongest and largest body of sufferers—the city's housewives. Call it what you will—"health nuisance" or "common nuisance"—to this body of our citizens it is a condition that confronts each individual member of that body. It comes home to her every day when she sees its sooty trail in the damage done to the furnishings of the home. To protect that home from this injury she is compelled frequently to close the windows, and by so doing prevent the admission of fresh air, itself an important adjunct in the preservation of health within the home. To the housewife it is a "common nuisance," and it would seem that the question could be treated in that aspect.

While more efficient legislation may be the best means of eradicating the evil, care must be taken that such legislation can be enforced without working too great a hardship upon the manufacturer. When these men are shown that abolition of the smoke nuisance is to their own advantage; that it means less coal consumption and smaller coal bills and the utilization of every pound of the combustible for the purpose of making steam, they will readily aid in, and respond to, all proper rules and regulations which may be enacted.

I have referred to Milwaukee as one of the moderately dirty cities,

and I recall having received a pamphlet from that place setting forth the great improvement there in smoke conditions brought about by legislation and the appointment of smoke inspectors. This pamphlet contained beautiful photographs presenting conditions after the improvements; and also photographs of before. During a recent visit to Milwaukee I was somewhat surprised to find conditions there much worse than in Philadelphia, and I believe we are better off without legislation than Milwaukee is with it.

While I have urged more efficient legislation, I would be glad to have a movement started from the engineer's standpoint along educational lines, demonstrating the proper handling of the fire in all its essentials—location of the grate, air-space between the grate and boiler, improved automatic stoking, etc. By these means it could be brought to the attention of the doubters and the unbelievers that eradication of the smoke evil is not only a public necessity and blessing, but that it is practical economy to large coal consumers and means the saving of dollars. I know of no better organization for the launching of this important public duty than the Engineers' Club of Philadelphia. Should this club decide upon such a course, it will certainly have every assistance and co-operation from the municipal Department of Health and Charities, and the heartfelt thanks of the health officials and the community at large.

James Christie.—The smoke nuisance is a never-ending problem with all cities whose principal fuel is bituminous coal. While the emission of great volumes of dense black smoke can be and is controlled and abated, yet it is never entirely prevented. Of the British cities, where every means of repression has been urged during the past century, all that can be said is that the nuisance is not so great as it would have been if the methods pursued for its repression had not been exercised. And yet it is a well-known fact that bituminous coal can be and is, under certain conditions, burned without the emission of smoke. The volatile elements which produce the smoke and soot are the first to be liberated by heat, and this distillation occurs at a much lower temperature than that of ignition; in fact, the distilling process is a heat-absorbing or temperature-lowering process in itself. Furthermore, the particles of carbon which form smoke ignite and burn reluctantly, and at a high temperature only, as can be observed with soot or lampblack—an amorphous form of carbon formed by the condensation of smoke. A result of these peculiarities is that when smoke is liberated above the fire under

ordinary conditions, it escapes into the atmosphere unconsumed, and the smoke nuisance is established. If, however, the volatile hydrocarbons, or smoke-creating elements, are compelled to pass through a mass of the incandescent coke, they are at once raised to the ignition temperature; and if then supplied with the requisite oxygen, combustion is effected, and this is more or less complete, according to the perfection of the system used. On this principle the best forms of mechanical stokers and smoke-preventing furnaces depend, such as the horizontal-fed, with the incandescent coke in front of the raw fuel; the down-draft, with the coke underneath; and the underfed system, with the heated coke above the raw fuel.

These devices were all anticipated in their intent by the invention of Watt a hundred and twenty years ago, whereby a dead plate or a coking retort was placed in front of the furnace, and the coked fuel alone burned on the grate, and through the incandescent coke the volatile elements from the coking chamber were compelled to pass.

In 1758 Benjamin Franklin proposed to prevent the escape of smoke from pit coal by passing the smoke through red-hot coal, and, it is said, devised a grate to accomplish this purpose, showing that at this early date the many-sided man had some clear ideas on the subject.

All the smoke-consuming furnaces of to-day had their prototypes in the early years of the past century. Subsequent invention and improvement have only been in matters of detail, and yet the smoke nuisance is still with us—and probably will be so long as raw bituminous coal is used as fuel, for the reason that the various devices employed for smoke-prevention are not applicable to all furnaces. They are not applicable to steam locomotives, where the maximum amount of fuel must be forced through the furnace. They are not well adapted for the marine boiler, with its congested internal furnace; nor are they used, except to a limited extent, in domestic furnaces, and the latter contributes a large proportion of the smoke in cities where bituminous coal is used for domestic purposes. Furthermore, in some industrial works smoke is unavoidable to a certain extent, even when gas is used as fuel, for the reason that a reducing flame must be employed, an oxidizing flame causing waste or injury to the treated material.

In Philadelphia heretofore the smoke nuisance has not been serious, except in the vicinity of railroad terminals, as bituminous coal is not used for domestic purposes, and there is little excuse for the

emission of smoke from the furnaces of steam boilers. But this condition may not last. Anthracite coal advances in price, while the general tendency is for bituminous coal to go lower in price on the Atlantic coast. Even now the housekeeper could effect some economy by changing to bituminous coal. The time is probably not far distant when the change will become irresistible.

An English writer, discussing the smoke problem some forty years ago, could see no solution except by the adoption of gaseous fuel in cities. Since that time a new solution has appeared on the horizon through the introduction of the by-product coke oven. The innumerable products of gas-tar recovered by this oven are of such value, and in such great demand, that the coke product may become of secondary value, and in proportion to the thermal values the coke product may be offered at a lower price than the raw coal which produced it. In this way can be obtained a valuable and a smokeless fuel.

But coke, and especially that derived from the by-product oven, has decided limitations for most purposes. It is friable, light, and bulky, and not well adapted for rough handling or transportation. Here much can be learned from the Germans, who treat their inferior coals and lignites by briquetting, and convert them into an admirable fuel. Coke with an admixture of the raw coal, and a modicum of tar as a binder, can probably be briquetted into a smokeless fuel, suitable for any purpose, and produced at a price, that would drive the raw coal out of use. If this can be accomplished, the smoke problem will be solved in a simple and economical way. And not only the smoke problem, but possibly also the dust problem; and city dust, from a sanitary point of view, is more objectionable than smoke. Treatments of city roads by solutions of tar are the most effective means known for preventing a dusty atmosphere, and it is evident that a vast quantity of tar would be available if that wasted in the old type of coke oven was preserved.

E. M. Nichols.—About twenty years ago I was associated with a commission interested in the prevention of smoke. We made a test of two stokers in a battery of ten boilers. The same conditions prevailed at the time of this test; we had two stokers and two chimneys, and we made a test of coal from the same mine. In one set of boilers we used screened lump coal, and in the other slack pea coal. The slack was put in by the stoker and the lump coal was hand-fired by an expert fireman who was especially instructed to make

a good showing. The draft was the same, the consumption of water and fuel was carefully checked, and the four horizontal return tubular boilers burned coal from the same mine that was loaded into the cars the same day; and, as near as we could determine without any analysis, one was as good as the other. We developed under the two boilers with the mechanical stoker 10 per cent. more efficiency per pound of fuel, in pounds of water evaporated, and got 40 per cent. more work out of the boiler than we did with the boilers that were hand-fired in the same amount of time. The chimney which had the stoker was absolutely smokeless. I know that a smokeless condition can be obtained when using ordinary bituminous coal, except at the starting of the fires.

Howard S. Anders, M.D. (Visitor).—The public health is affected, disregarded, and neglected mainly along four broad lines of influence —governmental, industrial, commercial, and social. Of these, the first, or governmental influence and power, can do much or omit much in the control of the other influences and agencies relating to the public health.

The general disregard for the saving of life, and for the prevention of disease, accident, and needless discomfort in the daily walks, works, travels, and pleasures of the people is one of the amazing inconsistencies of our boasted civilization and practical Christianity. It is not to the purpose or relevancy of this occasion, however, to discriminate or enumerate the many ways in which this indifference and bustling neglect, sometimes almost criminal, are made manifest. Marked advances in the control and prevention of certain communicable diseases have admittedly been accomplished in the past ten or fifteen years; but they are but a threshold attainment to what yet lie before us untouched and unfinished.

There is, in our modern municipal life, a triad of unsanitary conditions, especially prevalent in Philadelphia, which calls for the steadiest and most strenuous agitation and action before we can expect materially to mitigate or annihilate them; these three evils are dust, smoke, and sputum; and they are closely allied, for much of the spitting habit with its attendant and added dangers is directly due to the abominable prevalence of smoke and dust.

There is only one other atmospheric annoyance and menace more dangerous than smoke, and that is dust; because the latter conveys infection, whereas smoke produces merely irritation. But the consequences of living in an atmosphere persistently or frequently

smoke-laden are so serious that it is of the utmost importance that such meetings as this should be more widely held, until the public demand and right for a clean air will have been met. The waste in coal unconsumed is trifling compared to the ultimate sacrifice of health and lives directly and indirectly because of the smoke evil.

Air vitiated by smoke contains not only the fine particles of tarry carbon, but more or less offensive, irritating, and inflaming carbonic and sulphurous gases. This is a matter of ordinary every-day experience and distress to those who ride in steam railway trains, or who live near our railways and railway stations.

Is it any wonder that respiratory diseases and diseases of the mucous membranes are so common and habitual in our big cities, where railways and factories daily pour forth such tremendous volumes of black smoke? Sore eyes and eyelids, catarrh of the nose, throat, and bronchial passages, may be produced directly by the mechanical irritation of smoke particles; and, when these conditions are the result of other excitants, smoke seriously aggravates the illness and tends to promote an incurable chronicity of the case. It is held by Aufrecht and others, the opinion being based on the study of certain cases, that bronchopneumonia is not infrequently induced by smoke irritation.

In these days of the popular and much-needed crusade against tuberculosis a special word needs to be said. Smoke does *not* produce this disease. The infective agent, the bacillus of tuberculosis, is carried in dust—*pulverized poison*, I call it—contaminated by dried sputum of consumptives. However, the smoke evil, if not a direct producer, is indirectly an important and serious predisposer to the disease. This happens in two ways: first, by local irritation of the membrane of the air-passages it sets up a catarrhal susceptibility to infection; secondly, by the habitual catarrhs and insufficient quantity of fresh air so contaminated by smoke the general systemic resistance to disease is diminished, and when the recuperative and reparative powers of the body are thus debilitated and weakened, the bacillus soon finds favorable soil and lodgment, and ready access to the vulnerable tissues.

It is well known, as has been pointed out by some of our noted physicists, such as Prof. Carl Barus, of Brown University, that our heaviest fogs and most heavily-laden humidities are caused by the presence of a nucleus of carbon or smoke, or of dust, surrounded by an envelope of moisture. That is the reason that London has so

many fogs, and why so many of our large cities where smoke is prevalent have such dense fogs. The smoke particles of carbon form ready nuclei for the formation of this most heavy air, and so the fogs are produced and the atmosphere becomes saturated with a heavy humidity, with a generally debilitating effect upon people living in cities; and, as Parkes has pointed out, when there is a fortnight of fog, the death-rate is increased to a marked degree.

In the spring of 1899 I studied the meteorological data for the preceding winter in relation to epidemic influenza; also, the data were compiled from the Weather Bureau reports of a period of ten years previous to 1890, and for ten years subsequent to that year. I wrote a series of papers on the subject, analyzing the separate phenomena, as atmospheric pressure, etc. It was found that there was a steady and uniform relation between the heavy fogs of January and February and the epidemic of influenza; it was also found that the fogs were largely due to the prevalence of smoke, and it was proved that the question of this smoke nuisance and the matter of public health conditions are closely related. Smoke causes irritation of the respiratory passages and renders the mucous membranes susceptible to the disease germs that may enter; and the inflammations produced sap the vitality of the tissues and lead to some general debility of the system.

The smoke problem is, then, important in regard to diseases that affect the mucous membranes, and we find, during the stagnant periods when there is smoke and fog, a larger percentage of carbonic oxid and acid gases in the air which counteract the effect of the fresh oxygen which we need, and the combination acts as a respiratory poison. On winter days when the cold winds are blowing, we have an irritating effect produced by the high north winds blowing particles of smoke down our throats and producing congestions.

There is also a psychologic side: We know that many of our housekeepers are much annoyed by the smoke nuisance. We all know, if the windows are kept open for a few minutes, on any street, in any part of the town, that papers or books exposed for a little while will soon look as though some one had sprinkled black pepper over them. It is destructive to all fabrics, and disturbs the serenity of our housekeepers. Our nerves are put at high tension nearly all the time; we work and play too fast and the strain upon our nervous system in our necessary work is sufficient and more, and we ought not to have such extra high tension imposed upon us daily, because of these evils that

prevail. The smoke nuisance is one of these, and it should be put down. It subtly, but nevertheless truly, nags and affects the health and physical stability of thousands of our women, and our men too; and therefore anything that the Engineers' Club can do to abate the smoke evil will contribute tremendously to the public health, and to the improvement and progress of the race toward bigger influence, activity, and usefulness.

John M. Lukens (Visitor).—Within the last four years there have been 279 smoke-consuming appliances installed in this city. The total number of boilers in actual use in Philadelphia is 7103, of which 4752 use hard coal and 2209 use soft coal; the remainder use other kinds of fuel.

In regard to the Pennsylvania Railroad locomotive yards in West Philadelphia, the railroad company has placed two of its best men in that yard in order to instruct the firemen and engineers in the proper handling and management of the coals used. They have reduced the smoke nuisance considerably, but have not been able up to the present time to prevent it entirely.

Action has been brought against fifty-six concerns for violation of the smoke ordinance, and penalties have been enforced against twenty-five of them. One hundred and seventy-seven firms changed from soft to hard coal during the last four years. At the present time there are only about two places on Market Street, between the Schuylkill and Delaware Rivers, using soft coal—the Bingham House and Blum Brothers.

The number of smoke inspections made from 1905 to 1909 was 8985, and much work is being done in Philadelphia toward smoke prevention.

Henry Leffmann.—I can add little, if anything, to this discussion, as the points have all been covered. The question may be simply stated thus: Can soft coal be burned with reasonable economy without appreciable smoke? If so, has not the community at large a right to insist on such a method even though it involves some expense to the user? It has been well said that, after all, the largest business in a city is housekeeping, and the housekeeper has rights which the municipal authorities ought to maintain. It is said that we must not interfere with manufactures, but we do so interfere in many ways in the interest of public comfort and public health, and why not in regard to unnecessary smoke?

Paper No. 1095.

THE DESIGN AND OPERATION OF A MODERN CLASSIFICATION YARD.

W. A. MacCART.
(Visitor.)

Read September 17, 1910.

The constantly increasing freight traffic of the country has carried with it the necessity for improved methods of handling it, and one of the most valuable of these has been the modern classification yard. To those members who are not identified with railroad work, and therefore do not understand what is meant by freight classification and its purpose, a few words of explanation may not be out of place.

Cars of freight destined to various points and accumulating either at original terminals or the various local freight stations along a line of railroad are brought to some point (such as where various routes diverge), the trains are stopped and such cars as are bound to a common destination, or for a certain use, are gotten together. This is termed classifying, and the purpose is, if possible, to secure a train-load of one destination or kind, which, if obtained, of course means that it will not require further stoppage or handling until the destination is reached. This separation of the various units comprising a train, or "cutting up" a train, as it is called, is done in three ways, viz.:

1. The original and most common way is by moving the train forward and backward, cutting off the cars during the process, and is commonly called "flat shifting."

2. By "poling," in which the train is handled by an engine at its rear, constantly pushing the train toward the classification tracks, while an engine at the front end on the adjacent track "poles" or pushes off the cars or "cuts" desired. This method requires the use of two engines, but the cars are constantly being moved in the proper direction.

3. By the "gravity" or "hump" method, as it is generally designated, in which the train is pushed up to a hump or elevation, at which

point the couplings are cut or separated at the proper places and the cars proceed to the proper classification tracks, impelled, after leaving the "hump" or apex, by the more or less steep descending or momentum grade.

Within the past ten or fifteen years a great number of yards have been built or remodeled for operation by this method, and Mr. C. L. Bardo, in a paper prepared by him and published in the Journal of the New York Railroad Club, December, 1903, gives the relative capacity of the different methods of shifting as follows, based on handling a train of sixty cars of fifty cuts in each case.

Push and pull, or flat shifting	required	two hours.
Poling	"	one hour and fifteen minutes.
Hump method	"	thirty minutes.

It will readily be seen that if there is any volume of traffic, it can be handled with greater success by the latter method.

It is believed that the first place at which gravity was used as a factor in shifting or classifying was Edge Hill, near Liverpool, England, on the London and Northwestern Railroad. This yard was built in 1875, and is still in active operation. A description of it is to be found in the "Engineering News" of May 31, 1894. The operation by gravity was not the original purpose of its construction on a grade, but to avoid a very great cost in graduation necessary to obtain a level yard. In fact, as history goes, its proposed operation by gravity was strongly opposed because of the supposed danger to both men and equipment.

The Edge Hill yard can scarcely be classed as a hump yard, which implies a hump or apex (usually artificial) over which the cars are pushed to the momentum grade. At Edge Hill the trains are received at the top of a long grade, from which they are dropped through the various classifying and making up operations solely by gravity; no engines being used from the time trains are received until they are made up ready to proceed on the road.

It is generally recognized that the first place in this country to which the "hump method" was applied was at the Honey Pot yard of the Pennsylvania Railroad Company, located near Nanticoke. This is the point at which is assembled and classified a large percentage of the anthracite coal shipped from the Wilkesbarre district over the Pennsylvania Railroad. The hump, which is a compara-

tively low one, was built about May, 1891, and has been used ever since with excellent results.

The sketch plan (see insert) shows in a general way the relative location of the various features common to most yards, and a yard designed for the classification of cars by moving them in both directions, the operation in either direction being practically the same.

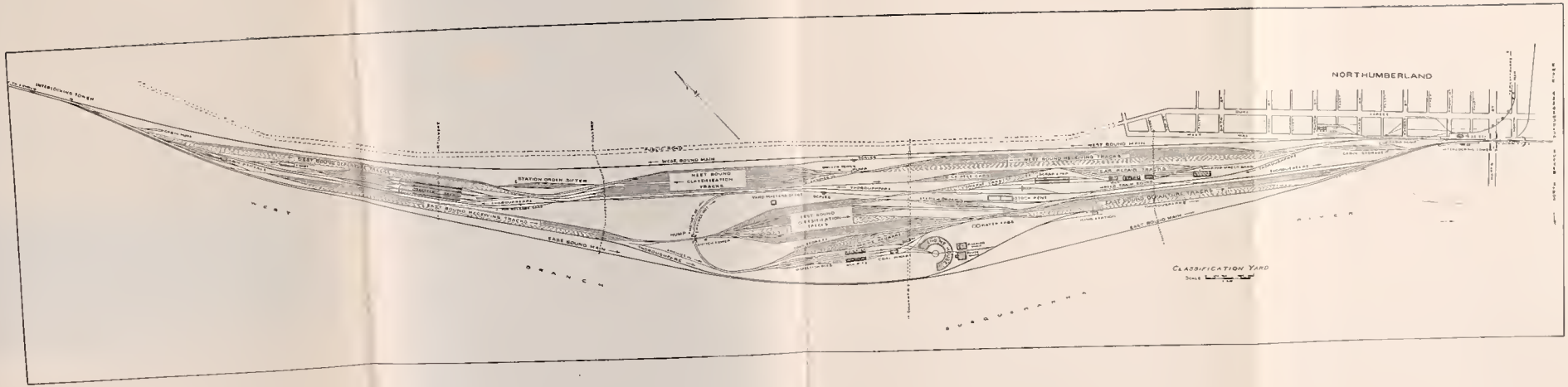
The operation in general is as follows: After a train leaves the main track and enters the receiving tracks the crew is relieved, the road engine is cut off, and at once proceeds to the inspection pit, ash pit, coal wharf, and engine storage tracks in the order named, so as to be ready for a departing train when needed, the train thereafter being handled by the yard force until again ready for the road. The movement from and to trains from the engine facilities should always be free, as many serious delays to traffic have been caused by the inability to turn the power promptly.

Having the proper facilities, four hours should be sufficient time in which to clean, make such light repairs or adjustments as are needed, and have an engine ready for the return trip. The storage tracks for engines are arranged with comparatively short lengths so there will be a minimum of shifting to get at any particular engine that may be required.

Returning to the train that is on the receiving tracks: it is at once inspected and the cars marked for the proper classification tracks, including those requiring such repairs as cannot be made at this point. In some instances very light repairs that can be made quickly are made on the receiving tracks as the inspection progresses. Upon the completion of the inspection and the removal of the cabin from the rear of the train the hump engine gets behind it, and when the proper signal is given proceeds to push it over the hump. The storage tracks for cabins are sometimes arranged so that cabins can be dropped into them in "first in, first out'" order as fast as they reach the receiving tracks.

On the ascending side of the hump is stationed a man to cut the couplings between the different classifications. Here also the brakemen, or "riders," as they are termed, take charge of the respective cuts and ride them so as to control the speed down-grade into the classification tracks.

Fig. 1 shows a side view of a hump and illustrates very clearly its elevation in comparison with the general level of the rest of the yard shown in the foreground, this elevation being required to secure the


NORTHUMBERLAND
WEST BOUND MAIN
EAST BOUND MAIN
STATION ORDER SIDING
WEST BOUND CLASSIFICATION TRACKS
WEST BOUND CLASSIFICATION SPIDER
WEST BOUND RECEIVING TRACKS
WEST BOUND RECEIVING TRACKS
CAR PLAIN TRACKS
STOCK PENS
EAST BOUND MAIN
HUMP
CLASSIFICATION YARD
SCALE
BRANCH
SUSQUEHANNA
RIVER

grades necessary to propel the car into the classification tracks. It also shows the spacing of the cuts of four cars each as they follow each other down the grade.

Fig. 2 is a view looking down from the hump into the classification tracks. In the foreground at the right appear three tracks, the central one over which the cars pass into the classification tracks diverging from it, and on each side the parallel tracks upon which the poling engines work, the cuts in this operation being pushed away from the front end of the train. From the tower at the left are operated by

Fig. 1.—Side view of a "hump."

levers the first nine switches at the divergence of the ladder tracks. The classification tracks can be seen with the low signal at switch of each where it leaves the ladder track.

Classification tracks, as a rule, are assigned to destinations, although in some instances for a specified purpose, such as accumulation of empty cars for the coal or coke regions, refrigerator cars, shop or bad order cars, etc.

The number of cars to a cut varies greatly with the nature of the traffic; in some instances trains are entirely broken up into single-car cuts; at others as many as ten or twelve cars are coupled in one cut.

To control its speed each cut, of course, requires a brakeman or "rider," as it has been already stated they are called (in some locations they are termed "car droppers"). In the large cuts it is usual to allow four to six cars to the man.

The prompt and inexpensive return to the hump of the "riders" after taking their cuts to the classification tracks is in itself quite a problem, for upon that, and upon being ready to take another cut, depends largely the speed with which cars can be passed over the hump, without having an unduly large force of riders. This is ac-

Fig. 2.—View from "hump" to classification yard.

complished in some very long yards by having an engine and car to pick up the "riders" along the classification tracks and bring them back to the hump. In short yards they generally walk back, and either a large force of riders must be kept on hand or the movement must be slowed up. It is really a question of whether the movement is sufficiently large or important to have a force of men who will be idle part of the time, or an extra engine to return them to the hump.

The moving of the switches leading into the classification tracks is done in different ways, the most complete, and of course expensive, method being what is known as the "push button machine." The

switches are thrown electro-pneumatically by a man located in a tower near the hump, commanding a general view of the train as it approaches from the receiving tracks, and the ladders and switches leading to the classification tracks, and the various switches are moved by their correspondingly numbered push button, as required to set up a route for the car. In the views shown, however, lines of pipe leading to a half dozen or more switches are connected to levers concentrated at one point and operated by a leverman. If there are many classification tracks, of course, more than one leverman is required. At the location illustrated there are twenty-two classification tracks and three levermen's towers, the one at the apex having two men and taking care of nine switches; the other two, farther down the ladders, taking care of six and seven switches respectively.

As previously stated, the cars or "cuts," as they are termed, whether there be one or more cars coupled, are marked with chalk as they stand on the receiving tracks, to designate the number of the track to which they are to be sent. This number is placed on the side of the car at the front end, and oftentimes it is the practice to also mark on the rear of a cut the destination of the next following one. This serves as advance information to the leverman. The leverman, or towerman, is also furnished with a slip, similar to that used in marking the cars on receiving tracks, showing the "cuts," number of cars in each, and their destination.

The cars are pushed over the hump at the rate of about two and one-half miles per hour, but to prevent their following each other too closely because of running on the same ladder or lead, the tower is equipped with a large air-whistle by which the towerman can signal to the pushing engine to stop the train, and start again when sufficient separation of the cuts has been obtained. The whistle can also be used in case of accident or other emergencies.

As the classification progresses, so fast as a sufficient number of cars of one or several classifications combined accumulate, they are gotten together, the air-hose coupled and brakes tested, a road crew and engine called for, and the train started on its journey. In some yards this is done by the yard force collecting the cars from the classification tracks into "make-up" or advance tracks, where they are coupled and the air-brakes tested to insure that everything is in proper order before the road crew couples on. At other points the road crews take the cars as directed from various classifying tracks and get them together on a drill or pull-out track.

As can be readily understood, the yarding and classifying of a train means a considerable delay, and it is desirable, therefore, that the yard be so located that the classifications made will permit the longest possible haul without again breaking up the train, so as to avoid this delay, damage to equipment, etc.

As a rule, a yard layout embraces a movement in both directions, and as there are a great many internal movements, such as getting road engines and cabins to and from their trains, getting shop cars to the repair tracks and back into their trains, possibly re-icing refrigerators, caring for stock or weighing certain cars, etc., all of which must be done with the minimum amount of interference with other movements, the importance will be seen of sufficient thoroughfare tracks upon which to make such movements promptly.

It will be noticed in the general plan shown (see insert) that the main tracks are spread and the yard placed between them, this being the preferred location, for the reason that as soon as an incoming train clears the main track, there is no further interference with it.

Every yard is a problem in itself, for which there are a few general principles that apply. The length of arriving and departing trains, the character of traffic, the number of classifications to be made, whether a large or small percentage of the cars require weighing, and many other features must be considered in each place.

In a paper of this character it is possible to give only a general outline of this method of shifting, for the reason that every yard plan requires a special study to meet the conditions. For instance, the length of trains passing over that portion of the road from which the yard receives and to which it delivers traffic will determine the length of receiving and departure tracks; whether the cars are all loaded, all empty or mixed, affects the rate and length of grades on the hump. These grades are also affected by the number of cars to the cut, whether a scale on the hump is necessary, and all these conditions in turn are affected by climatic conditions, as a car runs more freely in August than in January.

DISCUSSION.

Mr. MacCart.—In reply to the questions raised by Mr. Develin, Mr. Swaab, Mr. Milner, and other members of the society, I would say that a description of the mechanical hump and track scale and its operation will be given by Mr. Epright, who is much more competent to do so, he being the designer.

The poling operation is usually done on a level or slight grade where it is necessary to give cars a start, and has the advantage of no backward movement to the

whole train being required (as in push and pull shifting), due to the poling engine moving on a track adjacent to the train that is being shifted. In some cases the pole is attached to and pivoted on the pilot beam at the front of the engine, but the more common practice is to pole the cars from a "poling car" attached to the locomotive, and upon which a man rides and operates the pole, which is six or eight feet long, suspended and pivoted at the sides of the car in such a way as to reach the pole socket castings of cars on the adjacent track. A rear engine is generally used to keep the train pushed up to the point of operation where the poler can give the cars the necessary impetus to carry them into the classifying tracks.

As to the grades to be used on humps, that is a problem to be decided for each yard and is governed by several factors: viz., whether all loaded, all empty or mixed cars are being handled; whether any portion are weighed, requiring a scale installation; whether the cuts are single cars or composed of four or five cars. The climate also has an effect, there being a decided difference in the running qualities of cars in January and August.

If you are designing a yard to be used for all loaded or all light cars, the question of grades is simplified, the loaded running on lighter grades than the empty ones.

There is practically no difference in the distance traveled by the various cars going to different classifying tracks, as each starts at the hump and leaves the outgoing end of the yard.

In a classifying yard containing thirty tracks, by splitting them up into five or six ladders the farthest switch will not be more than 700 or 800 feet from the hump.

The speed of the cars is controlled by the riders, and the initial momentum must be sufficient to carry a car through the ladders and switches and the full length, if necessary, of a track with a standing capacity of sixty or even more cars, while other tracks may not have a capacity of more than twenty cars. A rider cannot permit the speed for a car going to a track partially filled, that he would when he started to fill the empty track.

As to the expense of upkeep, I am not aware that it is any greater than for the ordinary yard. In the beginning of hump installations there were probably a great many cars broken, but not after the men became accustomed to the work, and our present records show less car damage than with the other methods of shifting.

In the earlier days the men would ride the cars down the momentum grade, set the brakes to what they thought would permit the car to go to its destination, and then return to the hump. The conditions now are that the men ride the car to a coupling with the car already on the siding, controlling the speed the entire distance. This makes a slower process unless you have a large force of men, as they get farther from the hump and require a longer time to get back.

This brings up the problem of getting the riders back to the hump quickly. At some points an engine and car is used to collect and return the men. A moving sidewalk has been suggested as a solution of the problem.

The keeping of yard records has been beneficial, inasmuch as by them it is possible to locate the particular man responsible for damage to cars, and this naturally makes them more careful.

A. W. Epright (Visitor).—A mechanical hump provides simple and effective means whereby, with the minimum of attendance for and skill in manipulating

the cars, the latter may be passed rapidly and without stoppage over the platform of the weighing scale with the proper velocity to permit each car to be weighed as it passes over the scale platform, regardless of variations, within the usual limits, in the lengths of successive cars.

To accomplish this, the track over which cars pass to the scale platform is provided with a hump having a fixed apex at a short distance from the adjacent edge of the scale platform. The slope is so proportioned at the side of the hump adjacent to the scale to the distance of the apex from the scale platform and the rate at which it is desired to weigh the cars that when the cars are pushed at a uniform rate up the side of the hump remote from the scale, and are uncoupled from each other before or while being pushed up the hump, each car will run down the hump and on to the scale platform with the proper velocity to permit it to be accurately weighed.

It is a matter of common knowledge that the cars passing over a railway scale located at the head of a classification yard are not of one pattern, and in particular that the distances between the front and rear wheels vary in different cars. With the advent of the mechanical hump, however, this variation in wheel-base length is, in a measure, automatically compensated for. When the side of the hump adjacent to the scale platform is short, as it should be, the increase in velocity acquired by the cars running down that side of the hump varies inversely with the length of the wheel-base of the car, other things being equal.

This is as it should be, for the interval in which a moving car may be weighed is that between the time when the rear wheels pass on to the platform and the time when the front wheels pass off, and, in order to keep this interval down to the desired minimum, cars having a long wheel-base should move more slowly across the scale platform than cars having a shorter wheel-base.

For rapid and accurate weighing it is desirable to have the scale platform and the adjacent side of the hump as short as possible, and in practice it has been advisable to make the side of the hump adjacent to the scale platform about equal to the distance between the centers of the wheel-trucks of the cars having the shortest wheel-base.

In the design of the hump it has been so constructed that the elevation of its apex above the scale platform can be adjusted in order to get the desired relations insuring proper rates of speed of the cars on to the scale platform. For instance, the elevation of the hump required in a given installation depends upon and changes with the season. In the winter, when everything is taut from contraction, the apex of the hump should be somewhat higher than in the summer-time, when the cars form less rigid structures. The lubricant also becomes stiff, which affects the free running of the cars.

With reference more specially to yards in which nothing but loaded cars are classified and weighed, or at points where necessity demands that loaded cars should be weighed and empty cars classified over the same hump, a compromise may be effected by changing the elevation of the apex.

It is, of course, a familiar fact that it has been a common railway practice to provide artificial humps in classification yards using track scales, to facilitate the distribution of cars, etc., but the mechanical hump provides a track running to the scale platform, having its apex at a fixed and determined distance from the scale platform. It also provides a structure of such a character that the slope of

the hump and the location of its apex will not be changed in time, either by the cars which pass over the hump forcing the cross-ties down in the ballast, or in the repairing of the road-bed and track by the trackmen, and, so far as is known, the mechanical hump installed at West Brownsville Junction (Monongahela Division of the Pennsylvania Railroad), in connection with the track scale (52 feet in length) recently installed in the new classification yards at that point, is the first

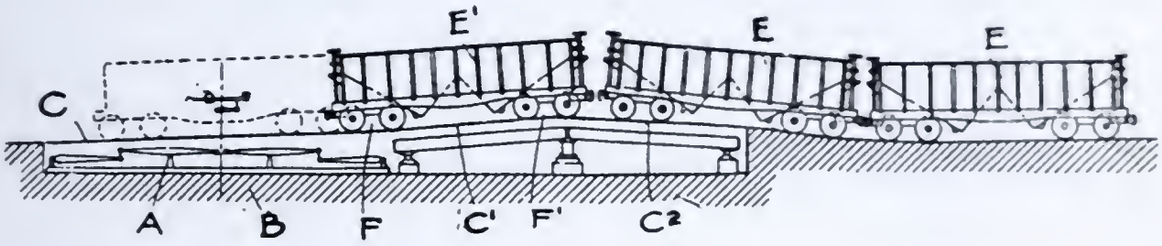


Fig. 1.

to provide a hump structure in which the elevation of the apex of the hump can be definitely adjusted as desired.

At the scale and hump layout, West Brownsville Junction, a new feature, at least so far as American practice is concerned, has also been introduced in connection with the scale construction. A mechanical relieving gear is provided,

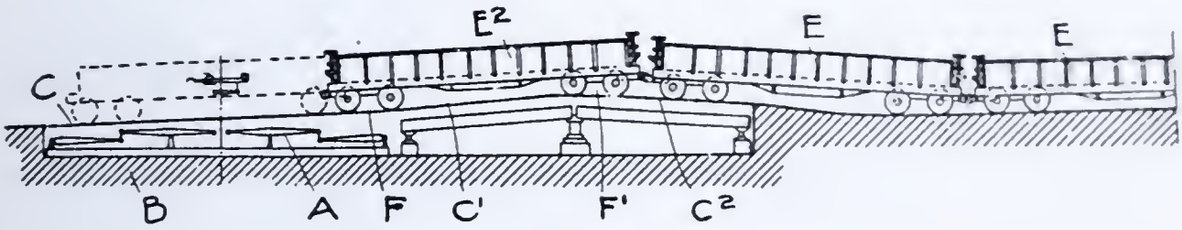


Fig. 2.

which, when operated by the weighmaster (either by hand or by power), makes a dead-track out of the scale-track, thereby doing away with the two sets of rails over the scale, as well as the cumbersome columns which support the old type of rigid dead-rail, also the tracks and switches on the approaches leading to and over the scale, which are the cause of many derailments, and which necessitate the

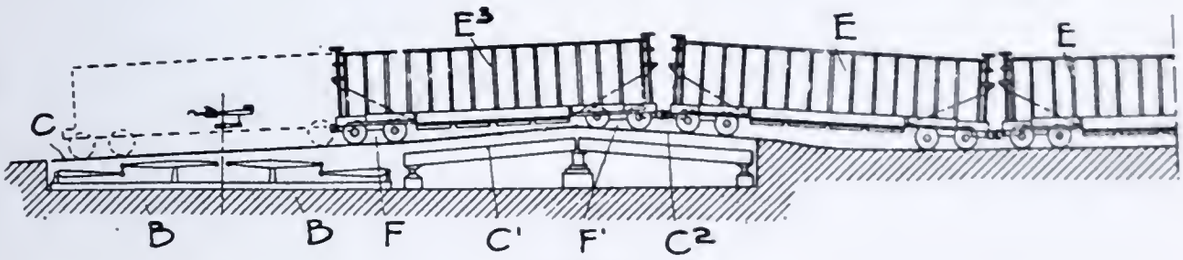


Fig. 3.

throwing of the switches and the consequent pulling back of the train in order to get it on to the dead-rail track. All of these objectionable features are eliminated by this new device.

For a better understanding of the invention, however, and the advantages possessed by it, reference may be had to the accompanying drawings (Figs. 1 to 6) and descriptive matter.

Fig. 1 is a diagrammatic elevation showing a scale track hump and a car having a short wheel-base passing over the hump on to the scale platform. Fig. 2 is a view, similar to Fig. 1, but showing a car having a wheel-base of medium length passing to the scale platform. Fig. 3 is a view, similar to Figs. 1 and 2, but show-

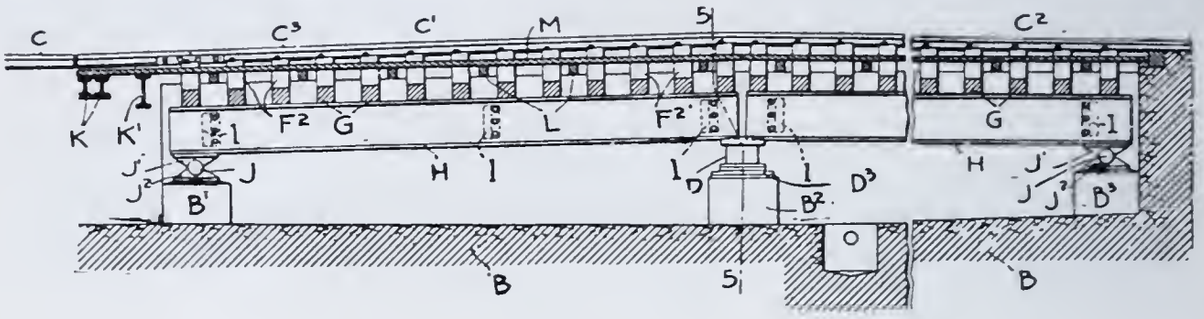


Fig. 4.

ing a car having a long wheel-base passing to the scale platform. Fig. 4 is a longitudinal sectional elevation through the hump. Fig. 5 is a transverse sectional elevation taken on the line 5—5 of Fig. 4, and Fig. 6 is a view taken similarly to Fig. 5, illustrating a modified construction.

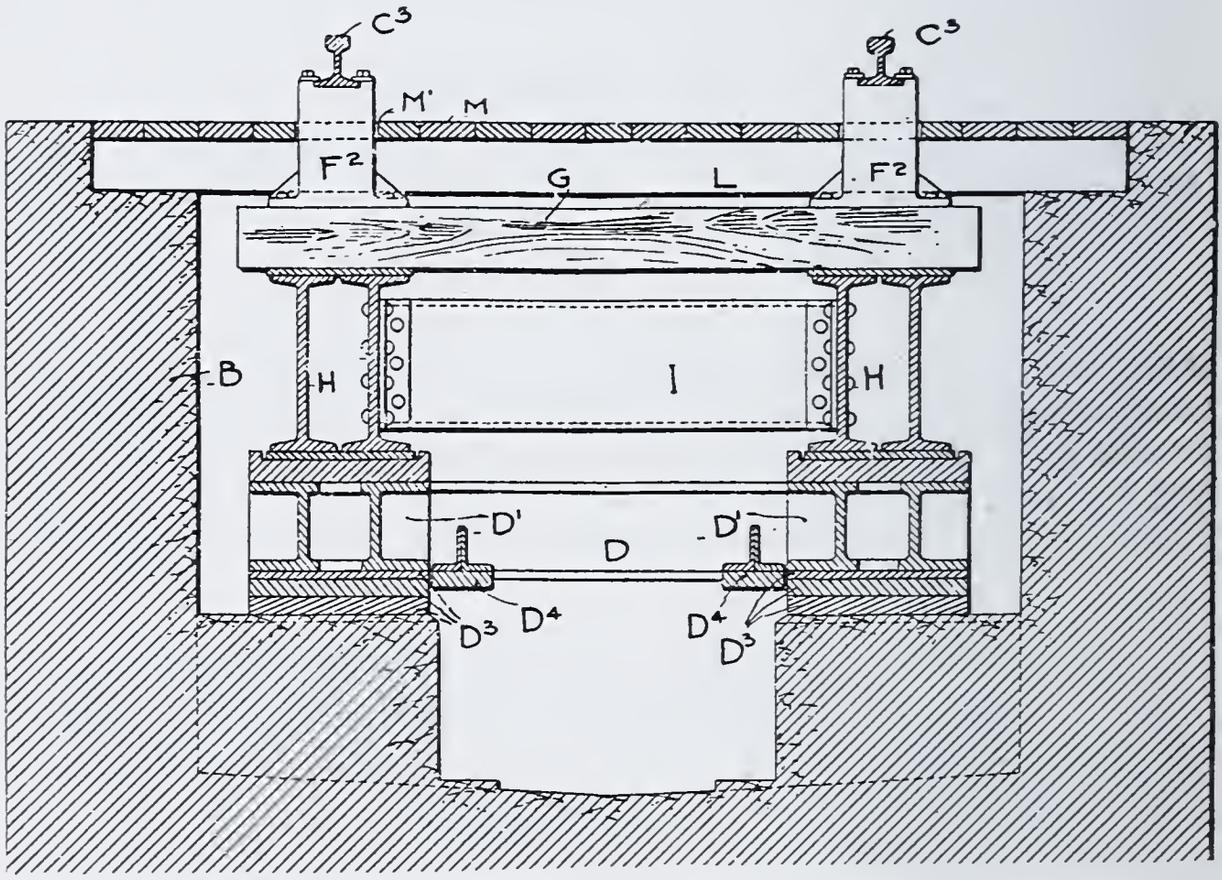


Fig. 5.

In the drawings, and referring first to Figs. 1, 2, and 3, A represents the scale; B, the wall of the scale-pit, the bottom of which is shown as horizontal; C, the track section supported by the scale platform; C^1, the track section of the side of the hump adjacent to the scale platform; and C^2, the track section at the side of the hump remote from the scale. In each of these figures a car is shown, the front

truck, F, of which has just passed from the hump onto the scale platform. The distances between the front and rear trucks, F and F^1 respectively, of the three cars, E^1, E^2, and E^3, shown in Figs. 1, 2, and 3 respectively, are different, the wheel-base of the car E^1 being shorter, and the wheel-base of the car E^3 being longer, than the wheel-base of the car E^2. Each of the cars, E^1, E^2, and E^3, is uncoupled from its pusher; the uncoupling may advantageously be accomplished when the cars are being pushed up the inclined track section, C^2.

It will be apparent from an inspection of these drawings in connection with what has already been said that the velocity of the car E^1 in passing over the scale will be greater, and the velocity of the car E^3 will be less, than the velocity of the car E^2 in passing over the track section C if we assume that the velocities of the

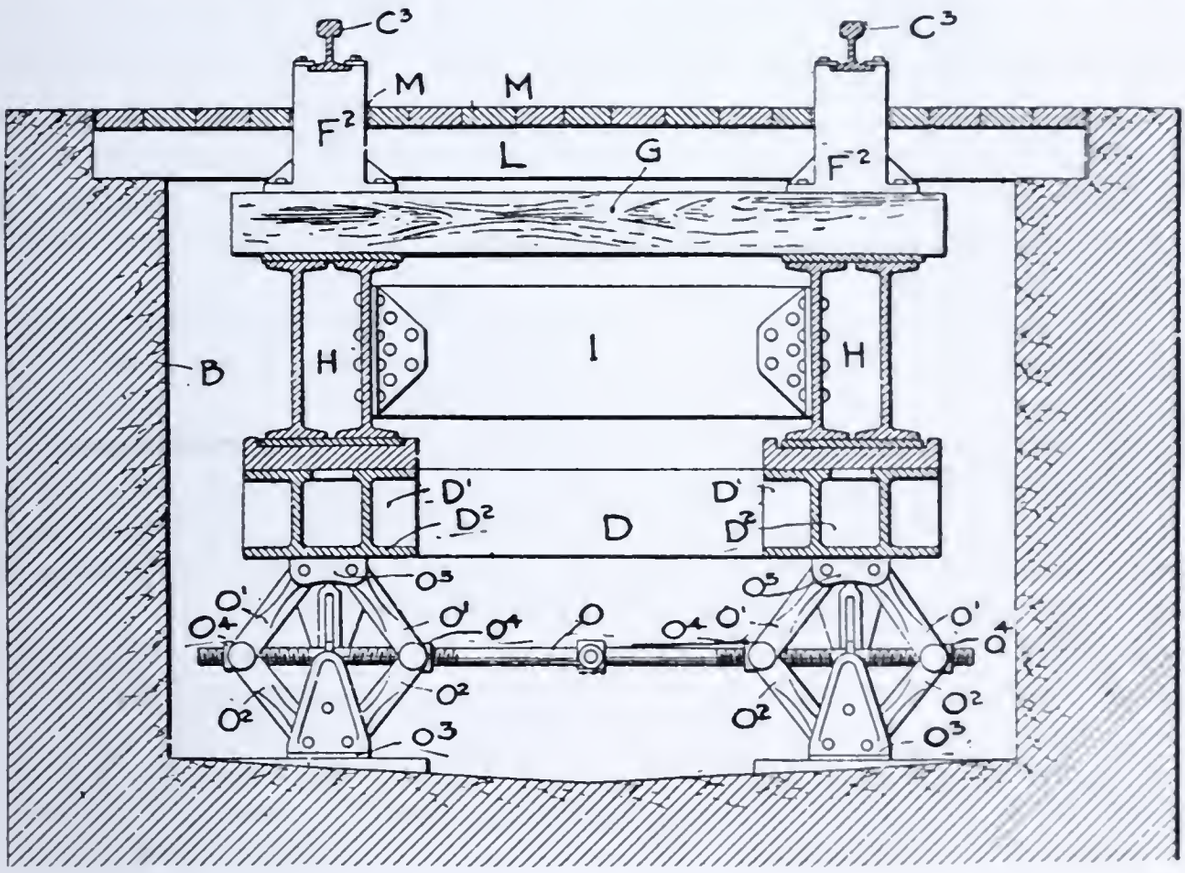


Fig. 6.

cars E, which have pushed the cars E^1, E^2, and E^3 up the hump, are the same, and that other conditions are the same in the different figures.

It will also be apparent that with a given velocity of movement both trucks F and F^1 of the car E^1 will be on the scale platform a longer time than will both trucks of the car E^2, and that both trucks of the car E^2 will be on the scale platform longer than will both trucks of the car E^3, and that when the inclination and length of the track section C^1 are properly chosen with respect to the suitable velocity of movement of the pushers E, the periods during which the front and rear trucks of each of the cars E^1, E^2, and E^3 are on the scale platform may be made substantially equal. This equality of weighing periods may be obtained also without requiring the setting of the brakes or other attention on the part of the operatives.

The preferred form of construction of the hump which is employed, in order to

maintain the distance between the apex of the hump and the scale platform constant in a simple, reliable, and effective manner, and at the same time to provide suitable means for adjusting the apex of the hump vertically, is illustrated in Figs. 4, 5, and 6.

The track rails, C^3, proper, pertaining to the hump structure, are supported on chairs, F^2, which in turn are mounted on the usual cross-ties, G. The cross-ties, G, for the hump section, C^1, are supported on the upper edges of the beams H, which, in the form shown, are built-up beams made of rolled metal shapes, and these beams are tied together by cross-braces, I. The lower ends of the beams H pertaining to the hump section C^1, are pivotally supported at J through hinge members, J^1 and J^2, the hinge members J^1 being connected to the beams H, and the hinge members J^2 being supported by abutments, B^1, rising from the bottom of an extension of the scale-pit, B. The lower end of the hump section C^2 is pivotally supported in a similar manner.

The upper ends of the beams H of the two hump sections, C^1 and C^2, rest upon an adjustable support, D, which is mounted in the form shown in Figs. 4 and 5 on an abutment, B^2. It will be understood, of course, that the abutments B^2 are beneath the apex of the hump, and in the usual form are located about midway between the abutments B^1 and B^3.

In the form of the apparatus shown in Figs. 4 and 5, the adjustable support D comprises a beam, D^1, having enlarged end portions, D^2. Spacers, D^3, support the end portions, D^2, and rest upon abutment B^2, and these spacers may be increased in number or may be replaced by others of different thickness in order to give the desired vertical adjustment. The beam, D^1, is provided with ears, D^4, under which the tops of jacks, not shown, may be placed in order to raise and lower the member, D^2, to permit the spacing blocks, D^3, to be adjusted. D^4 represents seats which may be provided for the jacks.

The ends of the track rails, C^3, adjacent to the scale platform may be supported on stationary cross-beams, K and K^1. The chairs, F^2, project through apertures, M^1, in a stationary platform, M, which is supported by suitable beams, L.

The means for adjusting the elevation of the apex of the hump, shown in Figs. 4 and 5, have been found quite satisfactory, for it will be understood that under certain conditions of use, at least, the adjustment required is needed only at comparatively long intervals. Where it is desired, however, an adjusting mechanism may be provided in which no separate jacks are needed, and such a mechanism is shown in Fig. 6, where the upper members, O^5, of the pair of jacks, O, are permanently secured beneath the ends, D^2, of the cross-beam D^1, and the links, O^1 and O^2, connecting the top member, O^5, with the base, O^3, of each jack are provided with nuts, O^4, in the usual manner, receiving the threaded ends of the common cross-bar, O, by means of which each pair of links, O^1 and O^2, may be moved toward and away from the position in which they are aligned in the usual manner of operating toggle jacks.

IN MEMORIAM.*

WASHINGTON JONES.

Our venerable fellow-member passed away on the 30th of last July in the eighty-ninth year of his age, retaining his usual activity until within a few days of his demise.

Mr. Jones was born in Philadelphia on February 22, 1822, and became an apprentice at the works of Merrick & Agnew, at the early age of fifteen years; it is said being the first apprentice taken in that establishment. His industry and capacity were attested by his advance to positions of responsibility there and in several other engineering works of this city, such as the Southwark Foundry, Merrick & Towne, and the Penn Treaty Works of the Neafie & Levy Ship and Engine Building Co. He was associated with the Port Richmond Iron Works of the I. P. Morris Company, as Constructing Engineer, from 1856 to 1891, with a brief interruption of a few years at the Southwark Foundry, and bore an important part in the productions of that establishment during the Civil War.

Mr. Jones became a member of The Engineers' Club in May, 1882, and served as President in 1886, and was elected an Honorary Member in 1908. He was a member of the American Society of Civil Engineers; Member and Vice-President of the American Society of Mechanical Engineers, and was the oldest surviving member of the Franklin Institute, having been a member continuously since 1847, and was a Vice-President of the Institute at the time of his death.

* Prepared by James Christie and Henry J. Hartley.

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, September 17, 1910.—The meeting was called to order by President Easby at 8.35 p. m., with 86 members and visitors in attendance. The minutes of the business meeting of June 4th were approved as printed in abstract.

The President announced the deaths of Mr. Washington Jones, Honorary Member, and Colonel Silas G. Comfort, Messrs. George W. Hayes, and William D. Beatty, Active Members of the Club.

On motion of Mr. Rondinella, it was ordered that a committee of three be appointed to prepare a memorial of Washington Jones.

The Committee on Nominations, viz., Henry H. Quimby, Chairman; Thomas C. McBride, William C. Kerr, Henry Leffmann, W. B. Riegner, John C. Parker, and E. M. Evans, proposed by the Board of Directors at the meeting of the Club on June 4th, was approved.

The Board of Directors presented to the Club several amendments to the By-Laws.

A Memorial of Colonel Silas G. Comfort, prepared by Captain St. George H. Cooke and Thomas C. McBride, was presented by Captain Cooke. Colonel C. E. Hyatt also presented a tribute to Colonel Comfort.

Mr. W. A. MacCart, visitor, presented the paper of the evening, entitled "The Design and Operation of a Modern Classification Yard," which was discussed by Messrs. R. G. Develin, S. M. Swaab, S. E. Fairchild, Jr., Morton M. Price, H. C. Berry, and others.

Business Meeting, October 1, 1910.—The meeting was called to order by President Easby, at 8.35 p. m., with 118 members and visitors in attendance. The minutes of the business meeting of September 17th were approved as printed in abstract.

Following a report of the tellers, the President declared the following elected to membership: Active, David Walker Jayne, William J. Spencer; Associate, Gaston Daus, Richard G. Park, Jr., William Wallace Scott, Jr.; Junior, Hobart B. Baird, John Thornton Dean.

A memorial of Washington Jones, Honorary Member and past President of the Club, prepared by Messrs. James Christie and George B. Hartley, was presented by Mr. Christie.

Mr. D. T. Randall, visitor, presented the paper of the evening, entitled "Smoke Abatement," which was discussed by Dr. Joseph S. Neff, Dr. Howard S. Anders, Dr. Henry Leffmann, Messrs. John M. Lukens, James Christie, E. M. Nichols, P. A. Maignen, and John C. Parker.

Business Meeting, October 15, 1910.—The meeting was called to order by President Easby at 8.20 p. m., with 156 members and visitors in attendance. The minutes of the business meeting of October 1st were approved as printed in abstract, except that the name of George B. Hartley, appearing as one of the

committee to prepare a memorial of Washington Jones, should be given as Henry J. Hartley.

The several amendments to the By-Laws proposed by the Board of Directors at the meeting on September 17th were brought up for discussion, and, on account of the time required, it was ordered that the discussion of the amendments be continued at an adjourned business meeting, to be held November 5th, prior to the regular meeting of the Club.

Captain Curtis W. Otwell, visitor, presented the paper of the evening, entitled "Military Engineering," and, following its presentation, upon motion of Captain Cooke, the thanks of the Club were tendered to Captain Otwell.

Adjourned Business Meeting, November 5, 1910.—The meeting was called to order by President Easby at 8.25 p. m., with 40 members in attendance. The discussion of the amendments to the By-Laws proposed at the meeting of the Club on September 17th, and brought up for discussion at the meeting on October 15th, was continued at this meeting. After several of the more important recommendations had been defeated, it was moved by the Secretary and carried that the entire list of amendments be rejected.

Business Meeting, November 5, 1910.—The meeting was called to order by President Easby at 8.45 p. m., with 118 members and visitors in attendance. The minutes of the business meeting of October 15th were approved as printed in abstract.

Following a report of the tellers, the President declared the following elected to membership: Active, Edward T. Grendlienard; Junior, George H. Borst.

Dr. Henry Leffmann, Active Member, presented the paper of the evening, entitled "The Building of a City," which was discussed by Messrs. J. M. Weiss, B. A. Haldeman, Henry Hess, W. C. Furber, J. E. Fulweiler, J. C. Trautwine, Jr., John C. Parker, D. K. Boyd, and others.

Mr. John C. Parker suggested that the Board of Directors appoint a committee to arrange for the holding of monthly meetings for the consideration of such municipal affairs as involve engineering, and, following this, it was moved and carried that the sense of the meeting was in favor of this suggestion.

Business Meeting, November 19, 1910.—The meeting was called to order by President Easby at 8.40 p. m., with 98 members and visitors in attendance. The minutes of the adjourned business meeting and of the business meeting held Saturday evening, November 5th, were approved as printed in abstract.

The president announced the death of Mr. J. Walter Ruddach; elected active member December 21, 1907, died November 6, 1910.

The Committee on Nominations presented the following list of nominations for officers of the Club for the year 1911:

President	James Christie.
Vice-President	W. L. Plack.
Directors	St. George H. Cooke.
	R. G. Develin.
	Richard Gilpin.
	J. A. Vogleson.
Secretary	W. P. Taylor.
Treasurer	F. H. Stier.

Mr. Alexander Simpson, Jr., presented the paper of the evening, entitled "The Chief Engineer as Interpreter and Arbitrator," which was discussed by Messrs. W. C. Furber, S. M. Swaab, John C. Trautwine, Jr., H. M. Chance, W. F. Ballinger, John C. Parker, G. S. Cheyney, and others.

On motion of Mr. Trautwine, the thanks of the Club were extended to Mr. Simpson.

Business Meeting, December 3, 1910.—The meeting was called to order by President Easby at 8.35 p. m., with 96 members and visitors in attendance. The minutes of the business meeting held Saturday, November 19th, were approved as printed in abstract.

On application of twenty-five active members of the Club, Dr. Edgar F. Smith was proposed for Honorary Membership.

Following a report of the tellers, the President declared the following elected to membership: Active, Frank Rodney Pleasanton; Associate, Joseph W. Mackay, Harry N. Payne; Junior, John Christian Graf, Fletcher K. Wilkinson.

Mr. A. L. Moorshead presented the paper of the evening, enttiled "The Erie Railroad Four-track Cut and Tunnel Line through Bergen Hill, Jersey City," which was discussed by Messrs. T. H. Boorman, H. C. Berry, B. Sullivan, J. C. Trautwine, Jr., Richard Gilpin, E. M. Nichols, and others. On motion of Mr. Nichols, the thanks of the Club were extended to Mr. Moorshead.

Regular Meeting, December 17, 1910.—The meeting was called to order by President Easby at 8.30 p. m., with 139 members and visitors in attendance. The minutes of the Business Meeting held Saturday, December 3d, were approved as printed in abstract.

Mr. Rudolph Hering, Active Member, presented the paper of the evening, entitled "Some Late European Experiences in Water and Sewage Works and Refuse Destruction," which was followed by a short paper by Mr. George S. Webster, describing some of the features of the sewage disposal plant now being constructed at Holmesburg. Following a short discussion, on motion of Mr. Webster, the thanks of the Club were extended to Mr. Hering.

The meeting adjourned, upon motion, at 10.35 p. m.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Regular Meeting, October 13, 1910.—Present: President Easby, Directors Ehlers, Cochrane, Plack, Swaab, Hutchinson, Mebus, the Secretary, and the Treasurer. The minutes of the regular meeting of September 16th were read and approved.

The Treasurer presented a brief report on the financial condition of the Club.

The Secretary reported that the contract with the accountants, C. W. Todd & Company, had been extended for a period of three months, to expire December 31, 1910.

The Committee on House reported that it had leased the meeting-room to the local sections of the American Chemical Society and the Institute of Electrical Engineers at stated times throughout the year, at a price of ten dollars a night and three dollars additional for the use of the lantern.

It was ordered that the President and Treasurer be authorized to negotiate a loan of one thousand dollars to be expended in improvements to and furnishings for the Club-house.

It was ordered that the trustees of the Bond Redemption Fund be authorized to cancel the second mortgage bonds owned by the Link Belt Company and held by the trustees, and that credit for this amount be placed upon the books of the Club.

The resignations of Messrs. H. McM. Dibert and Charles H. Ott were accepted as of July 1, 1910.

Regular Meeting, November 17, 1910.—Present: President Easby, Vice-Presidents Christie and Hess, Directors Ehlers, Cochrane, Plack, Swaab, Mebus, Wood, Halstead, Worley, the Secretary, and the Treasurer. The minutes of the regular meeting of October 13th were read and approved.

The Treasurer presented an informal report on the financial condition of the Club.

Mr. Charles F. Knight was reinstated to active membership.

The resignations of Messrs. William J. Cooper and A. Warren Way were accepted as of even date.

Mr. John C. Parker's suggestion, made at the last regular meeting of the Club, tha a committee be appointed to arrange for the holding of meetings for the consideration of municipal affairs, was referred to the Committee on Meetings.

The Building Committee presented a progress report.

Regular Meeting, December 15, 1910.—Present: President Easby, Vice-President Christie, Directors Ehlers, Develin, Plack, Swaab, Wood, Halstead, Worley, the Secretary, and the Treasurer. The mintues of the regular meeting of November 17th and of the special meeting of November 26th were read and approved.

The Treasurer presented the monthly report of the accountants for the preceding month, and also a statement of the present financial condition of the Club.

Following this report, it was ordered that the following extract from the minutes of the adjourned meeting of the Board held July 14, 1910, be rescinded:

"It was ordered that the President and Treasurer be authorized to negotiate a note, in amount not exceeding $2500.00, to liquidate the floating indebtedness."

It was further ordered that the President and Treasurer be authorized to negotiate a note in amount not exceeding $2500.00, for a period of sixty days, to liquidate the floating indebtedness.

A letter from Dr. Henry Leffmann, Chairman of the Trustees of the Bond Redemption Fund, relative to payments of initiation fees, was read and referred to the Treasurer.

The matter of the renewal of the contract with the accountants, C. W. Todd & Company, was discussed, and it was ordered that a committee, consisting of the chairmen of the Finance and House Committees, the Secretary, the Treasurer, and the Treasurer-elect, be appointed to consider this matter, and to make the necessary arrangements on or before the first of the year.

The question of the members delinquent in house charges was discussed, and was referred to the House Committee for report.

The House Committee presented an informal report on various matters connected with the management of the house.

Following the reading of the letter from Mr. John C. Parker, relative to request for the use of the meeting-room for meetings of the local section of the American Society of Mechanical Engineers, it was ordered that this matter be referred to the Committee on House, with power to remit rent for the meeting-room for the first meeting, if necessary.

The following resignations were read and accepted: Active, Ambrose G. Warren, A. A. Stevenson, James B. Ladd, B. H. Coffey, C. A. Lindstrom, N. W. Sample, Jr.; Junior, Alwin F. Huch; Associate, Thomas S. Genay.

The following Junior members were transferred from Junior to Active membership, to take effect January 1, 1911: William J. Pollock, F. C. Hubley, Frederick Haag, Jr., Frederick S. Crispin, S. Atlee Bockius, and Edmund G. King.

The Building Committee presented a final report, which was referred back to the Committee for revision.

Adjourned Meeting, December 29, 1910.—Present: Vice-Presidents Hess and Hewitt, Directors Ehlers, Develin, Plack, Swaab, Mebus, Halstead, Worley, the Secretary, and the Treasurer.

The resignations of Messrs. T. B. Genay, Clayton W. Pike, and A. H. Bromley, Jr., were read and accepted as of December 31, 1910.

It was ordered that in the future all resignations received be referred to the Committee on Membership prior to action by the Board.

Mr. F. G. Myhlertz was dropped from membership in the Club, and the Treasurer was instructed to collect his delinquent account.

Mr. William C. Kerr was elected an auditor of the Club, vice Mr. C. H. Ott, resigned.

The Secretary announced that, following a count of the letter ballot, Dr. Edgar F. Smith had been elected to Honorary membership in the Club.

The work of the Executive Committee was discussed, and it was ordered that meetings of this Committee be held on January 7th at 7 P. M. and January 19th at 7 P. M.

A letter from Mr. Thomas C. McBride was read, tendering his resignation as Chairman of the Committee on Increase of Membership, and, following acceptance of Mr. McBride's resignation, Mr. Henry Hess was elected temporary chairman. It was ordered that this Committee on Increase of Membership be empowered to add to its number at its discretion.

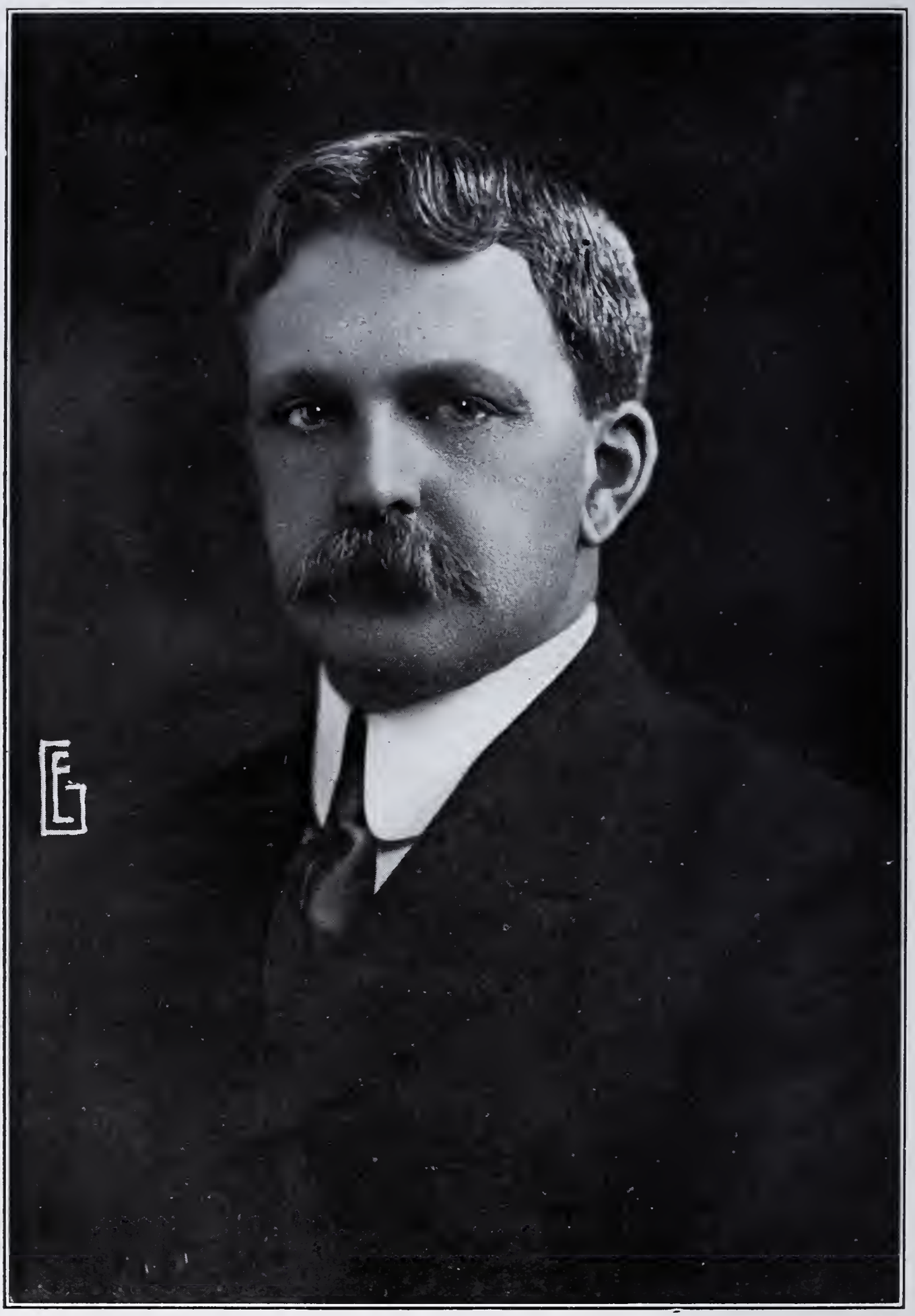
The Building Committee presented its final report, which was accepted and ordered to be spread upon the minutes of the Club. The Building Committee was then discharged.

It was ordered that all donors of material to the Building Committee be endered the thanks of the Board.

It was moved and carried that the Treasurer and Chairman of the House Committee be instructed to obtain an inventory of the house furniture and fixtures.

It was ordered that the Trustees of the Bond Redemption Fund be invited to meet the Board at its next regular meeting, to consider a revision of the method of retiring the second mortgage bonds.

On motion of Mr. Worley, it was ordered that the Board express to the commanding officer of Company "B," Engineer Battalion, its appreciation of the standard of excellence maintained by that organization during the past year, as shown in the annual rating of the National Guard.



William Easby, Jr.

Thirty-third President of the Club, February 5, 1910, to February 4, 1911.

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXVIII. APRIL, 1911. No. 2

PRESIDENT'S ADDRESS.

THE BEGINNINGS OF SANITARY SCIENCE AND THE DEVELOPMENT OF SEWERAGE AND SEWAGE DISPOSAL.

WILLIAM EASBY, JR.

Annual Meeting, February 4, 1911.

SANITARY science embraces all those branches of knowledge in which are considered special measures for the preservation and promotion of the health of individuals and communities. Of its constituents, medicine is perhaps the oldest and bacteriology the most recent. Sanitary engineering, regarded as a distinct branch, is a development of the last generation.

To fully appreciate the profound and wide-spread improvement in the general health of communities through the agency of clean water, clean food, clean air, and a medical science demanding the segregation of those sick of contagious diseases, we have but to turn through the pages of the history of civilization, where may be found records of devastating plagues, the victims of which are to be numbered by the millions. From the viewpoint of the present age, in which all occurrences are attributed to natural causes, and in which nothing is regarded as fortuitous or supernatural, it seems indeed strange that the primitive causes of this appalling waste of life were not generally recognized and their operation opposed by the medical

science of the times, such as it was. The causes of this lack of self-preservation have been presented most convincingly by the historian, and furnish one of the strangest chapters in the annals of civilization.*

Reason founded on scientific observation and research is of comparatively recent growth. Prior to its development, man attributed the many occurrences in his universe, which he could not understand, to supernatural causes. Sickness and death were regarded either as punishments imposed by an offended and almighty being, or as the results of the machinations of evil spirits. Escape was sought through propitiation and offering and through the protection of fetiches and signs, which were most effective when in the hands of the priesthood, who therewith wrought miracles of healing. Men's minds were so fully imbued with belief in the miraculous, through tradition and teaching, that but few sought a natural cause for sickness and pestilence and the operations of nature in general, and to those who did, those who were in advance of their age, theological superstition too often awarded the martyr's crown. To the bitter opposition of the Church to reason, a force so destructive to its theology, through which it controlled men, may be charged the slow growth of general science, more particularly the science of medicine, in the early history of which we have the beginnings of sanitary science.

As early as 500 B. C., Hippocrates laid the foundation of medicine on a much more rational basis than that of his day, and his teachings were afterward accepted and extended by the school of Alexandria, where the study of human anatomy is believed to have had its beginning, giving a knowledge of the human organism which corrected many absurd and erroneous notions. In southern Europe the healing art was fostered in the tenth century by the school of Salerno, where hygienic principles especially were developed, and later by the school of Montpellier, both under the guidance of Jewish physicians. From about the tenth to the fourteenth century the Arabians, particularly those in Spain, devoted much thought to medicine and chemistry. The little true progress made in medicine, up to the middle ages, lay largely outside of Christendom, where the authority of the priesthood was not so strongly felt.

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* "A History of the Warfare of Science with Theology in Christendom," Andrew D. White, vol. ii, chapters xiii and xiv.

Anatomical study, on which alone a sound medical science could be reared, was interdicted by the Church because it was held unlawful to mutilate the bodies of the dead, a belief coming down from the older pagan civilization and arising from the expectation of the resurrection of the body. In the sixteenth century Vesalius, under the protection of Charles V, took up the study of anatomy where it had been abandoned, and established, through his great talent and fidelity to truth, the foundation of modern anatomy. He declared untrue the belief in the missing rib from man, which had been claimed by the Church as evidence of the truth of the biblical narrative of the creation of Eve, and he also failed to discover a certain indestructible bone which was held to be "the necessary nucleus of the resurrection body." These disproofs of theological teachings, and disregard of the Church's opposition to dissection, were met by anathemas, if not by physical persecution, and Vesalius died an exile, while still in the prime of life.

Charges of atheism were brought against those whose researches tended to undermine the foundation of religious superstition, and physicians especially were held in extreme disfavor, being classed with sorcerers and magicians. This feeling was intensified by the fact that the healing art was for many centuries largely in the hands of the Jews. These people adhered to certain hygienic and sanitary principles received by them from the Egyptians and were not so strongly fettered by a belief in the supernatural nature of sickness and disease as those around them.

Several centuries later we find opposition from the same source manifesting itself in Europe against the practice of vaccination. However unsound this practice may have seemed from a medical point of view, it is surprising to find it opposed by theological thought worthy of the middle ages. In this country Dr. Boylston, about 1720, laboring in and about Boston to check the ravages of smallpox, was bitterly assailed from the pulpit for his "attempt to stay the judgment of God." Jenner, the discoverer of vaccination, met with like opposition. A conception of the vast value of his discovery to humanity is conveyed by the following quotation from a prominent English physician: "Jenner has saved, is now saving, and will continue to save, in all coming ages, more lives in one generation than were destroyed in all of the wars of Napoleon."

Until within quite recent generations pestilence in its most devastating form had reigned throughout Europe for hundreds of

years, generally originating in the East and free to enter along all channels of communication, unopposed by quarantine and unmitigated by habits of civic or of personal cleanliness. Streets and dwellings were indescribably filthy, and it was considered among the clergy a mark of great godliness to mortify the vanities of the body by totally disregarding all laws of personal cleanliness. From these preceptors the custom naturally passed to the people, taking a firm hold of their slothfulness.

To show how great was the loss of life in Europe from the fourteenth to the eighteenth century the following is quoted: "Such plagues as the black death and the sweating sickness swept off vast multitudes, the best authorities estimating that of the former, at the middle of the fourteenth century, more than one-half the people of Europe died, and that twenty-five millions of the people perished in various parts of Europe. In 1552 sixty-seven thousand patients died of the plague in Paris alone, and in 1580 more than twenty thousand. The great plague in England and in other parts of Europe in the seventeenth century was also fearful."*

The beginnings of sanitary engineering may be assigned to a very early date, if the construction of wells, the enlarging and walling up of springs, and construction of cisterns underground for the storage of rain-water, may be so regarded. Works of this nature of great antiquity have been discovered in India, Palestine, Egypt, and other eastern countries. Many of these were constructed in semi-arid districts as the only means of securing water, but in other localities watered by streams their construction, indicating a choice of sources, has perhaps some sanitary significance, although it is more reasonable to assume that the physical qualities of these purer sources and convenience of location had most to do with their selection. A connection between the use of impure water and disease had been observed, however, as early as the beginning of the Christian era, if not earlier, and to this may be largely attributed the construction of those most notable ancient sanitary engineering works, the aqueducts of Rome and those in various parts of the Roman Empire, the earliest dating back to 300 B. C. The Romans were not, however, the first to bring water great distances in aqueducts. They were preceded in this by the Greeks, and the use of earthen canals antedates records of any sort.

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*"A History of the Warfare of Science with Theology in Christendom," Andrew D. White, vol. ii, chapter xiv.

A regard for the public health is also shown in the construction of the extensive drainage systems which served in ancient times to remove ground-water and possibly organic wastes, and parts of which are still in use in Rome. Great expense was incurred, both in Rome and in its provinces, in the construction of aqueducts, which led from springs and mountain streams often at a distance. For supplies which were subject at times to turbidity, provision was made at the intake and at points along the route for removing suspended earthy matter by sedimentation, and in some cases salt was used as a precipitant. It was recognized that some of the supplies were better than others, and the best were used for drinking. Water was not introduced into the houses, but drawn from small reservoirs distributed conveniently throughout the city. The total length of the several aqueducts for the Roman water-supply was three hundred and forty-six miles, of which forty-four were carried on arches,* many of which were of imposing proportions and of great architectural beauty, as may be seen from existing ruins.

Of the drainage system of ancient Rome, little can now be identified except a few of the main outfalls into the Tiber, but Vitruvius states that they were provided for the whole city. In the crookedness of alignment and irregularity of grade and cross-section these old drains were faulty, being evidently built with no knowledge of the self-cleansing principle which is the most important consideration in modern sewerage design. Ventilation was evidently obtained through openings along the street and in public places where storm-water, and it may be wastes, were introduced. Excavations have failed to show any connections between these drains and the houses, but connections from latrines in the vicinity of the kitchen have been found.

The theory of the flow of water through pipes and orifices was based entirely on observation. As early as the first century B. C., Hero of Alexandria, as shown by his writings, knew that discharge depended on both area of cross-section and velocity, and that in conveying water through conduits of any kind, the greater the difference in elevation between the source and the point supplied, the greater would be the delivery. Frontinus and other Roman engineers who followed Hero seem strangely to have failed to profit in some respects by his observations. They saw no important relation between dis-

* "Journal of the Association of Engineering Societies," December, 1896.

charge and velocity, apparently believing that the former was proportional to the cross-section alone. Frontinus had noted the increase in discharge through orifices with increase in head, but he evidently regarded this relation as unimportant, since in his writings on the water-supply of Rome* he always compares discharges on the basis of cross-sectional area.

The practice of supporting conduits on masonry arches was in some cases abandoned in favor of inverted siphons, which were made of lead and of earthenware pipe as large as eighteen inches in diameter, encased in concrete, where the heads required. The remains of two of these structures, one at Lyons, France, which was subject to a head of two hundred feet, and another at Alatro, Italy, under a head of three hundred and forty feet, display great boldness, considering the nature of the materials employed.

In the centuries which succeeded the fall of the western Roman Empire, about 400 A. D., the progress of reason was checked by barbarian invasions and loss of liberty in almost every channel of human effort, and southern Europe was submerged in intellectual darkness for more than a thousand years. During this period the noble aqueducts, roads, harbors, and other works of engineering were gradually suffered to fall into disuse and decay, a condition expressive of the general decadence of the period. Throughout the fifteenth and sixteenth centuries intellectual and religious independence commenced to reassert themselves, stimulated by freer conveyance of thought through the agency of printing and by the broadening influence of the discovery of the "New World" by Columbus and the extension of discovery by other voyagers. Here and there, throughout the dark ages, the lamp of scientific advancement and reason was kept alight in an atmosphere of superstition and unreason, by the inherent and indestructible principle of human progress.

Society could be divided in a general way into the ruling class, largely composed of nobles and ecclesiastics, and the masses. Great palaces, castles, cathedrals, and monasteries were built from the taxes and labor wrung from the common people, for whom little was done to lessen the hardships of life or to maintain health by the establishment of public works. The sanitary condition of London from the early part of the fifteenth to the eighteenth century may be regarded

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* "The Two Books on the Water-supply of the City of Rome of Sextus Julius Frontinus," Clemens Herschel, 1899.

as typical of centers of population throughout northern Europe. The houses were generally small and poorly built, poorly ventilated and very dirty. The streets, which were narrow and usually unpaved, were made the depository of such refuse as the occupants did not care to retain indoors. "After nightfall a passenger went at his peril, for chamber windows were opened and slop-pails unceremoniously emptied down."*

The earliest sewers during this period were formed by walling and covering streams which had already been put to this use. Their alignment was crooked and the grade insufficient; the bottom being so rough that decomposing matter found an easy lodgment. As late as the middle of the last century the hydraulic principles, through the application of which sewers are made self-cleansing, were utterly disregarded; they were truly "sewers of deposit" and always made large enough to admit workmen to clean them. Prior to 1815 fecal matter was excluded from these sewers in an effort to protect the water-courses from contamination, but with the introduction of the public water-supply the use of sewers for the removal of this matter became compulsory. Up to 1847 the cess-pool and the dry-pail system were used. The danger to health of employing the first of these in populous communities and the offense arising from both were unavoidable conditions until the water-carriage of house-wastes became possible and also imperative through the general introduction of water into the houses. The plentiful and conveniently drawn supply of water for domestic and various other purposes, with the installation of water-carriage systems to remove it, marks an epoch in the sanitation of cities. The full benefit of sewerage, as a sanitary measure, was not at first realized, owing to faulty design and poor construction. Many sewers were, to use a frequently employed phrase, "elongated cess-pools." Within the last fifty years, from these defective beginnings there has been developed the modern well-built sewerage system, with cross-sections adapted in size and shape to widely fluctuating discharges, and with grades sufficient to give self-cleansing velocities. Although the hydraulic principles employed in modern sewer design are well understood, their most successful application depends on the accuracy of the values assigned to the factors involved. The engineer of today has at his command con-

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* "The Intellectual Development of Europe," John W. Draper, vol. ii, chapter vii.

siderable data on the run-off from storms, the dry-weather flow of sewers, the relation between velocity, grade, depth of flow, etc.; there is still demand for fuller information, particularly on the relation of rainfall to simultaneous run-off from city areas of various degrees of imperviousness.

Few questions pertaining to sewerage have in the past provoked so much discussion as ventilation. If sewers could be so constructed as to be completely self-cleansing, ventilation would still be necessary from the fact that sewage in transit, even though fresh, emits offensive gases. It was believed that the early sewerage systems functioned largely and directly in the dissemination of typhoid fever, cholera, and some other diseases, through the sewer air that gained access to streets and houses. The question of ventilation therefore seemed of vital importance. On the one hand, there was active opposition to the water-carriage system; and on the other, extraordinary efforts to overcome this defect. The methods used were, however, generally unsuccessful, such as the attempt to create a forced draft by the use of fans connected with the main sewers, the effect being entirely lost in the branches, which, collectively, had a much greater area. Tall stacks or "uplake-shafts" were used at the higher ends of sewers, or connections were made between the sewer crown and lamp-posts, to take advantage of the draft from the flame. All of these methods failed to take account of the forces naturally acting within the sewer resulting from the differences of temperature between the air inside and outside, the displacement accompanying a fluctuating flow, and other circumstances. As the nature of sewer air became better known, ventilation through perforated manhole covers and untrapped house connections came gradually into use, and these are the means generally employed today. Another important change for the better is the recent omission, in many cities, of the catch-basins, except where the street detritus is excessive, thus removing a serious cause of offense, with a reduction in cost of construction and maintenance.

Advancement in sewer design has naturally been accompanied with improvement in construction and maintenance. Smoothness of interior, regularity of cross-section of the sewer barrel, care to form curved and warped surfaces and intersections properly, solidity in construction, all influence the sanitary value of sewerage and receive now more attention than in the past, although much poor and slovenly work is still permitted. The worst defects are usually

found in the house connections and plumbing within doors. It is here that close supervision is most needed and often least secured. In even small and cheaply built dwellings open plumbing and porcelain or porcelainized fixtures have replaced in the bath-room, kitchen, and lavatories the old-fashioned boxed-in affairs, and care is taken to secure good ventilation and to promote cleanliness of walls and floors by giving them smooth, non-absorbent surfaces which may be easily washed. There is no better indication of the progress of enlightenment in sanitary matters than this care in the household, but improvement is still to be made in both the simplification of the layout of plumbing and the quality of the workmanship, which is often so poor as to be criminal.

In this age of active scientific research the best sanitary systems which can be designed today are sure to demand modernizing or radical changes in the near future; indeed, the latest developments in both sewage disposal and water purification indicate that in many instances we shall be able to secure sufficiently good results more economically than is usual at present, and still further improvements in methods may be confidently expected.

Probably the oldest record of the disposal of organic wastes is to be found in the Mosaic law, by which the burning of unclean matter and the burying of excreta are required. The gathering of people into camps and permanent settlements resulted in the formation of midden heaps, which have been found near-by ancient cities. Later, ditches were dug for the absorption of excreta, earth cast thereon, and the surface cropped with rank vegetation, which assisted in rendering unobjectionable these deposits. The small amount of liquids to be dealt with made it possible, by this method, to protect the sources of water-supply. With the introduction of water into houses other methods of disposal became necessary, and we find, next, large unlined pits or wells used for the reception of liquid wastes. These served fairly well if sunk in absorptive soils, not too close together, covered and vented; but where these precautions were lacking, the soil, in course of time, became waterlogged with a fetid mixture, which found its way under dwellings and into wells of drinking-water. Lined pits or cess-pools supplied with pipes extending to the house came next into use. The walls were purposely built dry to permit the escape of liquids and thus lessen the frequency of cleaning. This is still the method employed in parts of many of our large cities, and is more common in small places.

Great Britain has, since the investigations of the Health of Towns Commission in 1844, taken the lead in all questions pertaining to sewerage and sewage disposal. The publication of its investigations may be said to mark the beginning of modern ideas on these subjects. It described intolerably unsanitary conditions, which were widespread and which led in a few years to the removal of fecal matter by the sewers, from which it had, up to this time, been excluded.

The replacement of conservancy systems by water-carriage has resulted in the cleaning up of the soil and atmosphere in populous districts, but has, at the same time, imposed on them a sanitary problem of the first magnitude in properly disposing of large volumes of contaminated water. Kinnicutt has well said that "by water-carriage the problem of ultimate disposal is merely shifted from the individual to the community."

Other European countries have, since the middle of the nineteenth century, followed the lead of Great Britain in sanitary matters; some of them promptly, particularly Germany. Naturally, sewage disposal has not, in this country, made such general progress as in Europe, owing to less crowded conditions, and the extensiveness of many of our water-sheds. Fuller estimated that in 1905 a population of twenty-eight million was served by sewers, and but one million one hundred thousand by disposal plants.

The state of Massachusetts has since 1887, and until quite recent years, stood as a notable exception to the general indifference in the United States to the questions of sewage disposal and water purification. The published reports of 1890 of the experimental work conducted at the Lawrence station, under the authority of the Massachusetts State Board of Health, have become classics in the literature of the purification of contaminated waters. Reports from the Lawrence station have appeared annually since that date, describing improvements in existing methods and investigations along new lines of research, presenting by this time a great body of practical information which, though primarily intended for the benefit of the State, has found a very wide use throughout this country and in Europe.

The discovery, early in the last century, that yeast is a living plant led to a recognition of the fact that the decomposition of organic matter generally, as it takes place in nature, is associated with the vital activities of minute vegetable organisms. Not, however, until a generation thereafter was this relationship generally accepted, after the catalytic theory of Liebig and his followers could no longer with-

stand the accumulating proofs that decomposition required the presence of these organisms, as was shown so conclusively by Pasteur. Strangely enough, this biologic action was quite lost sight of in land treatment and filtration, where purification was regarded as a chemical oxidation and a mechanical separation of solids. Early in the seventies the Berlin Sewerage Commission stated that the formation of nitrates in sewage was a biochemic operation, and others showed that decomposition was always attended by the presence of bacteria and that anything which inhibited their growth or suppressed their activities interfered with the process. Furthermore, it was evident that these organisms were contained in great numbers in sewage, water, and earth. The recognition of these natural conditions marks the beginning of our present theories of biologic sewage-disposal methods, the fundamental principle of which is to utilize as far as possible these naturally occurring organisms. How this may be done most economically under various surrounding conditions is the problem presented wherever sewage is to be disposed of, and in an effort to solve it a tremendous amount of experimentation and research has resulted, representing the work of commissions, state boards, city departments, and individuals.

Considering the complex and unstable chemical and biologic nature of sewage, its analysis and examination at the various stages in the course of decomposition, with a view to detecting the causes of these changes, present unusual difficulties. Furthermore, the interpretation of results of analysis differs with different observers. In all important disposal projects it has seemed wise to proceed first along experimental lines, obtaining information *de novo* and confirming it, when possible, by comparison with any similar observations which can be found. From the view that purification is a purely chemical change, assisted by straining and sedimentation, the pendulum has swung to the other extreme, attributing to biologic action a much more important rôle than it deserves.

In response to the general sanitary awakening in England in the middle of the nineteenth century, sewage was removed from the city and applied broadly to land, with apparently but little thought of its final condition. These early efforts were more often than not a source of grave nuisance and stream contamination, and the avoidance of these undesirable results became the most important phase of the subject, as indeed it is today. The utilization of sewage by growing vegetation promised to mitigate these evils, leading naturally to the

development of sewage farming, which came to be conducted, however, quite as much with reference to securing a revenue as to purification. The general sanitary efficiency of the method was often sacrificed to protect crops, particularly when the rainfall was sufficient for their needs. Much stress was placed on the return of nitrogen to the soil by spreading sewage thereon, instead of committing it to the streams, where it was lost to vegetation. It has been estimated that as early as 1883 there were in England alone over two hundred irrigation tracts, and not a few on the Continent. The large sewage farms of Berlin and Paris, the latter covering fourteen thousand acres and the former still larger, are too well known to demand more than mention.

The tenacity with which land disposal has been adhered to in Great Britain, often under the most unfavorable climatic and soil conditions, has frequently been remarked. That this is the only proper method has been insisted on by the Local Government Board and maintained in opposition to equally good or better results obtained by other means. While its conservative position has acted as a safeguard in many instances, it has not, as has the Massachusetts State Board of Health, rendered assistance in developing and extending the theory and practice of sewage disposal.

Progress in land treatment was for many years retarded by a belief, founded largely on laboratory investigations, that the manurial constituents of sewage could be utilized at a profit in farming, losing sight of the fact that vegetation and the soil would be compelled to absorb large quantities of water to make these constituents available, often to their own injury. With a recognition of the limitations of land disposal the real progress in the method began. Much land is unsuitable for irrigation, and still more so for filtration. The capabilities of different sorts of soils, either cropped or uncropped, have by this time been studied under a variety of climatic conditions. The beneficial effect of removing suspended matter from sewage as a preliminary step, particularly where heavy land is used, the extent of the demands of different crops for sewage, the rotation of crops to prevent exhaustion of the land, the various uses to which they might be put, and many other matters, have received much attention from the standpoint of efficient disposal and of returns. Those English sewage farms on which Italian rye grass and other green forage crops are grown in proper rotation seem to give the best financial returns, particularly where, by means of ensilage, the green food is

preserved for feeding in winter. In no case, however, has the return equaled the sum of the interest on the investment and the annual operation.

If we except sewage farming in the arid and semi-arid districts, it is very doubtful if this method can recommend itself in this country on any reasonable grounds, considering our present knowledge of other methods. In comparison with the English practice there are a number of circumstances which render land treatment more difficult with us: The volume of dry-weather flow is from two to four times as great here, and while the sewage is weaker in about the same proportion, this advantage is much more than offset by the volume. Labor here costs more and the political control of municipal government is not conducive to stability in management or to general efficiency of labor. In spite of what may be said to the contrary, there is evidence that sewage farming and irrigation will be less in vogue in the future than in the past. In England, the home of sewage farming, the so-called biologic methods have come largely into use in the past ten years, either as part of a system requiring final application to land or filters, or used alone pending future developments. Regarding the large amount of capital invested in sewage farms in England and on the Continent, it may be expected that, with some modifications, the practice will continue where reasonably successful so long as the tracts in use have not sufficient value for other purposes to permit a recovery of the investment made.

It was found advisable, early in the history of land treatment, to remove, by sedimentation or precipitation, the suspended solids of sewage to avoid the surface clogging of the fields. As a result, larger quantities could be applied and better aëration obtained. Plain sedimentation was not as effective for this purpose as could be desired, and its defects in a measure led, in 1863 in England, to precipitation by the use of chemicals. More important, however, to the development of chemical treatment was the belief and expectation that in this way a high degree of purification would be attained, and at the same time the suspended matter and the precipitant would together form a fertilizer of sufficient value to more than return the expense involved. This expectation has never been realized, mainly because of the watery nature of the sludge formed, and it was also found that very little of the organic matter in solution was mineralized; the effluent was therefore subject to secondary putrefaction. In spite of these defects a large number of patented chemical processes

appeared, each claiming some special advantage, and all in the course of time yielding to the employment of the few compounds now generally used.

At the outfalls of the London main intercepting sewers about 300,000,000 gallons of dry-weather flow are chemically treated daily at an annual expense of about $1,000,000, and at Glasgow large extensions to the chemical precipitation plant were constructed after the biologic methods commenced to generally displace chemical treatment. These two plants are the largest of their kind in Great Britain, and no particular difficulty in getting rid of the sludge is experienced, as it is loaded into scows and dumped at sea. In this country, Worcester, Providence, and a few other places employ chemical precipitation to some extent, but this process does not find favor here, for while it produces a much clearer effluent than plain sedimentation, and in this respect is very favorable to subsequent purification on filters, fine or coarse, the sludge produced is 50 per cent. greater in bulk and the cost of the precipitant is considerable. As a final process it is permissible only when the stream or body of water receiving the effluent dilutes it sufficiently to prevent putrefaction; furthermore, the strong sewage of European cities admits of a more economic use of the precipitant than does the more dilute sewage of our cities.

Plain sedimentation for the removal of suspended matter has been conducted both continuously and by the fill-and-draw method, usually in shallow tanks in which the ebullition of gases from the deposit of sludge in the bottom has thrown some of it into re-suspension, interfering very seriously with the efficiency of the process. The avoidance of this difficulty has been achieved in the Emscher or Imhoff tank, which is so designed that the settled sewage and the sludge are practically separated from each other, the clarified sewage passing on in a fresh state, and the gases, which are not offensive, as they are in all other settling tanks, cannot escape through the entering sewage. The sludge from these tanks is free from offensive odors and contains less water than is usual. It is of a peaty nature and may be used for filling in low lands without giving offence. The tanks themselves, when in operation, are also so unobjectionable that they may be located in close proximity to buildings. This method of sedimentation has come prominently into use in the last two years, and doubtless has solved one of the most difficult problems in sewage disposal—the production of an inoffensive sludge. Its use in connection with

trickling beds has achieved a greater measure of success in the high-rate treatment of sewage than heretofore obtained.

Disposal by intermittent filtration on sandy tracts was probably first practised on a working scale by Baily-Denton, in Great Britain, as early as 1871, following experimental work in Germany and England which had been conducted for about five years preceding this date. By this process the bacterial oxidation of sewage by porous soils containing certain species of bacteria was fully demonstrated. It remained, however, for the Massachusetts State Board of Health, through its systematic and careful investigations, to give such prominence to the process as to command general attention. The publication in 1890 of a full report of the methods employed and results obtained with large experimental filters at Lawrence, Mass., showed that effluents of a high degree of purity, both chemical and bacterial, could be secured and at much higher rates than by irrigation, when the latter was conducted with proper regard for the quality of the effluent. Disposal by intermittent filtration is, generally speaking, available only where the proper sort of material occurs naturally, as artificial beds are far too expensive for economy except, possibly, where sandy and gravelly deposits are near the disposal site. Under carefully controlled operation, with filters properly constructed, nearly all organic matter is mineralized and a high percentage of the bacteria removed, the rate of filtration varying from 50,000 to 100,000 gallons per acre a day. Results as good as this cannot be obtained by any other practicable method yet discovered, but fortunately a much less degree of purification is often satisfactory.

The liquid wastes and excretal matter of communities have always, to some extent, found their way into streams and bodies of water, but the practice of disposal by dilution really began with the removal of such matter by water through extensive systems of city sewers. The intolerably unsanitary conditions attending this method, as usually practised, are well known, and, as we have seen, led in Great Britain and on the Continent to the development of land disposal.

The scientific establishment and general acceptance of the germ theory of disease in the last thirty years, as it relates to those diseases which affect the alimentary canal, must be regarded as marking another epoch in the history of sewerage and disposal. It explained the prevalence, at times, of typhoid fever, cholera, and other enteric diseases, and provided a rational basis for much that has been done empirically and for further progress.

It is well known that streams and bodies of water which have received sewage will in time purify themselves, but their ability to do so when receiving it continuously and in large quantities has been very much overrated. This is particularly true of most important streams which receive successive additions of sewage from towns or tributary streams located along their course. On the other hand, the dread of the dissemination of disease through public water-supplies, resulting from a full acceptance of the germ theory, has led many to the extreme position that sewage effluents must closely approach the standard of purity demanded for filtered water-supplies. If the sewage of cities were the only source of danger, this position would be more reasonable, but still impracticable in its application to large cities. Experience has shown that few water-sheds, however sparsely populated, are safe at all times as sources of public water-supply; it would therefore seem that most surface-water supplies must be either purified or sterilized—a view now gaining wide acceptance and leading to the correlated view that, save for exceptional conditions, a sewage effluent which does not render the recipient stream or body of water unfit for any purpose except for drinking in an unpurified state, may be regarded as satisfactory. This radical change in point of view does not correspond with a change in practice, as the grossest pollution of our streams has been permitted the country wide, until quite recently. The real progress of disposal by dilution, as with land disposal, is marked by the recognition of its most important limitations. A study of the factors involved shows that the amount of oxygen in the water must be sufficient for the purpose independent of the extent of dilution; that all oxygen is not available for oxidation, the effective quantity depending largely on the dispersing effect of currents and winds, on temperature and other conditions. We must also recognize that there is an apparent purification, due to dilution, *per se,* and a real purification resulting from bacterial oxidation in which the end-products are nitrates. The first is by far the more effective in nearly all cases.

The so-called biologic processes of sewage disposal came first prominently into notice about twelve years ago, and in England. Their origin there and development on a working scale resulted from the necessity of finding some method which might be offered the Local Government Board, either as a partial or as a complete substitute for land treatment, which, as already stated, was often poorly adapted to local conditions. The economic removal of sludge and

avoidance of ill odors where it is deposited have proved to be matters so difficult that it has been said the sewage disposal problem is the sludge problem. It was in an attempt to solve this problem that the septic tank was invented. Its early promises have not, however, been realized. Instead of liquefying and gasifying nearly all of the suspended organic matter, and also reducing some of that in solution, it has been found notably deficient in doing so in not a few installations, and where most successful the results have varied much with seasonal variations in the temperature, with the nature of the sewage, and with other conditions. Comparing the averages of a number of English tanks, the percentage of suspended matter removed ranges from 30 to 80, and it has been found that there is a progressive decrease in the proportion removed, as the accumulations in the bottom of the tank decrease the cross-section of the liquid above, thereby increasing the velocity through the tank. The discharge from the tank is not completely clarified, as much of the lighter flocculent solids are not settled out. By plain sedimentation the greatest removal of suspended solids does not exceed 80 per cent., which must be considered the maximum for the septic tank. Another claim made for the septic process is that it favors subsequent aërobic action, but this has not been established; in fact, the reverse seems to be the case. It seems to be the growing opinion that too little is known of the biochemic action which takes place in the septic tank to warrant the claim of its general availability or even of the constancy of results where already installed; indeed, there is evidence now that the claim of exclusive anaërobic conditions, on which so much stress has been placed, cannot be sustained, as tank effluents have at times contained dissolved oxygen. The preference is now for processes better understood and therefore more under control.

The contact treatment of sewage was developed in England on a working scale in 1893 at the London sewer outfalls at Barking and Crossness, being two years in advance of the practical use of the septic tank at Exeter, with which it has since been employed as a secondary and, in some cases, a finishing process. It may be regarded as an outgrowth of intermittent filtration established in this country by the Massachusetts State Board of Health about 1890, differing therefrom in the use of very coarse material in place of sand, with a consequent increase in the rate of from about 100,000 to 800,000 gallons, or more, per acre daily; and differing, further, in the retention of sewage in contact with the tank filling by closing the underdrains

instead of permitting it to pass continuously after each application. The contact period is inseparable from the use of coarse filling for the beds, as, without it, the large voids would permit the sewage to pass too quickly for purification. This, like other high-rate methods, gives an effluent which cannot compare favorably for purity with that from land treatment and filtration at their best, but the results meet the requirements in some places. A better purification may be had by passing the effluent to a second bed, and, for still better results, to a third, the rates for the whole area decreasing with each contact.

All of the factors influencing the efficiency of contact treatment have been investigated quite fully, covering the kind, size, and depth of filling materials; their original volume of voids and loss of volume with use, as well as the frequency of application of sewage and length of time required between such applications. The permanent loss of capacity of beds is the great defect of this system. The life of a bed is greatest when hard filling material is used and well clarified sewage is applied, intervals of rest being permitted for the oxidation of stored organic matter. The intermittency of the process, resulting in alternately anaërobic and aërobic conditions, is regarded as being fundamentally wrong, since the bacteria concerned in liquefaction and in oxidation require the maintenance of constant conditions for their most efficient work.

The greatest difficulty encountered in the use of the ordinary contact bed—the permanent loss of capacity—seems to have been successfully met by Dibden, by replacing the broken material used for filling, with slabs of slate laid in horizontal courses and separated by blocks of the same material, from one to two inches thick. In this way both the air space and capacity of beds is very much increased, the former leading to increased aërobic action. The freedom from permanent loss of capacity, beyond a certain point, and the restoration of the original capacity by flushing, which is favored by the separation of the slate slabs, has led to the construction of many of these beds in Great Britain, which have satisfactorily reduced the suspended solids, but those in solution are reduced less than in the beds employing the usual filling materials. A further very important advantage is the freedom of the deposits on the slate from offensiveness. It has been found that other organisms besides bacteria function in the purification effected, prominent among these being a small red worm which has been found in great numbers in all of the beds examined.

About twenty years ago the investigation of the Massachusetts State Board of Health at Lawrence showed that a high degree of purification could be attained with material as coarse as large gravel, if the rate was such that the sewage moved in thin films over the surface of the gravel, without filling the interstices. This principle is carried out in the trickling or percolating beds which are now used in several large plants in Great Britain, in Germany, and in this country. The tank filling generally used is, however, coarser than in the Lawrence tank, the rate much higher, and, as a result, the purification much less. Aërobic conditions are continuously maintained, and the oxygen of the air, the sewage, and the purifying organisms, which adhere to the tank material, are brought into the most intimate contact, an altogether ideal condition for aërobic purification, and one which has been sought by the introduction of air under pressure in beds of finer material with less satisfactory results, as in the experiments of Waring at Newport.

The employment of coarse filtering material renders the uniform distribution of the applied sewage difficult, since lateral flow, as in beds of finer material, does not take place to any extent, and it is therefore necessary to apply the sewage as a spray over the whole surface. This requirement is imperfectly met, either by traveling sprinklers, by revolving sprinklers, or by a multitude of fixed nozzles. As the purification efficiency suffers from non-uniformity of distribution, this feature of the design has been the subject of much experimentation. Trickling filters, like others, operate more successfully with settled than with raw sewage. The finely divided solids, which still remain in suspension after sedimentation, do not cause in them a permanent loss of capacity or clogging, as in contact beds and in filters of finer material. From causes not understood, trickling filters free themselves in warm weather from the organic matter accumulated in the winter, and thus obviate the great expense of removing, cleaning, and restoring the material with which the beds are filled, a consideration of the greatest importance in large installations. Non-putrescible effluents are obtained at rates varying usually from one to two million gallons per acre per day, which is three or four times as high as those obtained by double-contact treatment; furthermore, the effluent from the latter is not so well purified. Of all biologic methods of sewage disposal yet developed, the trickling bed seems the most promising. It is as well adapted to a wide range of climatic conditions as any, although there is some doubt of its success in very

cold climates, and can be operated at a much higher rate without clogging or losing capacity, and, being an aërobic treatment, it is not attended by offensive odors when properly conducted.

High-rate biologic methods of disposal do not give efficient bacterial purification. So far as normal water, soil, and many forms of sewage bacteria are concerned, this is not a matter of great moment, but as sewage is always open to, and frequently is infected with, certain disease germs, notably that of typhoid fever, such effluents are dangerous where the recipient stream or body of water is used in its unpurified state for a water-supply, or where the discharge is in the vicinity of bathing beaches and water-supply intakes. The large shellfish interests, such as those in the vicinity of Baltimore, also demand protection. In all of these cases the effluent must receive additional treatment before responsibility for it ends. Of the several methods which have been seriously considered, only chemical disinfection is practicable for large discharges, and of the considerable number of compounds which have been tried for this purpose chloride of lime, or bleaching powder, is used almost exclusively. In the quantities employed the biologic activity of filters or beds is not only not interfered with, but there results an improvement due to the suppression of the usual surface growths.

Rideal was the first to observe the fact that, while the cost of disinfecting crude sewage by the use of bleaching powder was too great for general use, the same is not true of partially purified effluents. It was also found that the destruction of the last few percent of bacteria increased the cost of the germicide out of all proportion the increase in efficiency. These developments have made the disinfection of the effluents from contact beds, trickling beds, and filters commercially practicable. Of great importance, from a sanitary point of view, is the fact that the strength of the bleaching-powder solution generally employed is destructive to the most objectionable sewage organisms, but not to the purifying bacteria in sprinkling beds. Use has been made of this discriminating effect in the sterilization of water-supplies, suggesting great economic possibilities in this branch of sanitary engineering.

In the foregoing pages, which relate to sewage disposal, an attempt has been made to present the principal steps in the progress of this important branch of sanitation, stating the advantages, limitations, and defects of the various methods which have been employed.

Paper No. 1096.

THE CHIEF ENGINEER AS INTERPRETER AND ARBITRATOR.

ALEX. SIMPSON, JR.
(Visitor.)

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It is evident, in considering the engineer as an engineer in relation to construction work, that he may occupy any one, two, or three of three essentially different positions; and that the principles of law which appertain to each one of the three are entirely distinct from those which appertain to the other two. He may be considered in the light of a draftsman, as draftsman of plans and specifications, in which respect he is acting simply as an engineer, and the relationship between him and the owner or contractor for whom he draws the plans and specifications will be simply that of employer and employee, and the law of employer and employee will govern. He may be a superintendent of construction, or interpreter of the contract, in which case he acts as agent for the owner or contractor, and the law of principal and agent will govern. He may likewise be an arbitrator, required to determine whether all the terms of the contract have been complied with, and what amount, if anything, is due to the contractor for the work he has done, and in that respect he occupies a quasi-judicial position, and the law relating to judicial officers applies to him.

Of course, those three different classes may necessarily, and often do largely, run into each other. For instance, an engineer who is engaged in superintending, no matter how careful the draftsman may have been, often finds that certain matters have been overlooked, and he has to alter parts of the plans and specifications, or make entirely new ones to cover the omitted parts, and it is well within his rights to do so.

As the subject shows, this paper will deal almost entirely with interpretation and arbitration. There is one thing, however, which may be said on the subject of the draftsman before going to interpretation or arbitration.

One of the difficulties which lawyers have met with, when difficulties have arisen, has grown out of the fact that an indolent engineer has

preferred to go to a pigeon-hole in his desk, or to an engineer whom he knows has done work somewhat similar in character to that which he is called upon to plan, to get some old dusty specifications which he uses with slight alteration, rather than take the trouble to prepare anew that which is really needed. As a result he gives no end of trouble. Such conduct reminds one of the fabled bed of Procrustes, whereof it was said, that if the man was too short to fit the bed, he was stretched until he did fit it, and if he was too long, a portion of his legs was cut off. The operation was a rather hard one for the victim, but relatively not more so than fitting old specifications to new work. One hesitates to carry the comparison any further, lest it might be said that inasmuch as the robber who planned the bed was the only one who obtained any pleasure out of the bed-fitting process, and as the lawyer is the only one who gets any pleasure out of the specification-fitting process, there must be a fellow-feeling between them.

When one comes to the question of interpreting a contract, there is one error which the engineer commonly makes right at the start. The specifications are found divided under various heads. Some are printed and some are written, and frequently the two appear to be in conflict. What, then, is to be done? It is quite easy, if one is acting for the owner, to accept that interpretation which most benefits him; or if for the contractor, to accept that which benefits him; but neither course is legal nor just. Under such circumstances one must make the seemingly discordant parts agree, if it is possible to do so; not one part, but the whole of the plans and the whole of the specifications must be taken into consideration, and the decision as to what is right must be made from what lawyers call the four corners of the instrument. Of course, if it turns out that the particular specifications and the general specifications so conflict that they cannot be made to agree, then the general must necessarily give way to the specific, for in that event the law says that the discordant general specifications must have been intended for some other part of the operation, and that because the specific could not possibly have been intended to apply to anything else.

Having decided that the engineer is going to interpret such specifications from all corners thereof, there are certain well established rules which assist him in that interpretation. It is a well-known fact that the same word used in different connections may have a different meaning. So here trade words must be given the trade

meaning. Every trade has its customs, and while the specifications may seem plain enough, the courts proceed, according to the notions of those who know nothing about the particular trade, to err in their construction, because they interpret the specifications not according to the usual meaning of the words used, but according to their meaning in that particular trade. To illustrate: A contract in a case that came up in the Supreme Court within the last few months spoke of the fact that the stonemason was to be paid $2.50 per perch for the stone measured in the wall of a building. That seemed very simple, but the jury were advised that there was a trade custom (in Delaware County, Pa., where the contract was made) to have the stone measured in the wall according to what is known as mason's measure, which meant a great deal more than simply measuring the exact quantity of stone. It meant that every doorway and window was to be measured solid, and every angle was to be measured double, and according to that method the contractor was permitted to recover about one-third more than he would have been entitled to if the wall had been so measured as to determine simply the amount of stone that was there.

Another thing was decided in that case. The contract was to be performed in Delaware County, and the proof, which was there made, was that that was the custom in Delaware County; but inasmuch as the general contractor was a Philadelphian, it was decided that he could not be expected to know what were the local trade customs of Delaware County, and hence he was not bound thereby unless advised thereof before making his contract. The question to be determined on a retrial of the case was whether it was a general or a local custom; if it was general, it bound both parties, and was the law of the contract; if it was local, it was not the law of the contract, because not binding upon the Philadelphian.

So there are terms as distinguished from customs, simply trade terms, which have meanings distinct from their ordinary meaning. I was surprised some years ago in looking through an English report to find that there was a dispute as to what was meant by "a thousand rabbits." Now one would think that a thousand rabbits was a pretty easy thing to define, but it was held that when a man contracted to sell a thousand rabbits in a warren, he had to supply twelve hundred or he broke his contract. Perhaps the theory was that while there may be a thousand rabbits in a warren today, the Lord only knows how many will be there tomorrow.

Half a dozen years or so ago I tried, in the Common Pleas Court of this city, the case of Guillon vs. Earnshaw, which case afterward went to the Supreme Court. It seemed simple enough, but it was not so simple as it seemed. A Philadelphia merchant bought three cargoes of iron ore, to be mined and delivered f. o. b. Carthagena, Spain. The contract said that the iron ore was guaranteed to contain 50 per cent. of iron in the natural state. But there came in a trade meaning which said that a guarantee of 50 per cent. in the natural state, was fulfilled by proof of the fact that there was not less than 45 per cent. in the natural state. The reason for that trade meaning was alike reasonable and plain when considered and understood. Inasmuch as it applies to another point which will be made later, and because it applies to terms frequently used in construction work, the following illustration is given.

If a contract is made for a supply of gravel or of sand, or of trap-rock, or of anything else that nature alone supplies, one may say any number of times that the materials supplied must be the best of the kind and must be uniform in quality, yet it is evident that exactly what is contracted for cannot be had, because natural products vary more or less in quality. Consequently the trade meaning was allowed to be proved there, as it would also be allowed to be proved in the illustration given. To strictly construe a guarantee of 50 per cent. of iron in the natural state would mean that if the iron assayed 49.5 per cent. or 50.5 per cent. the buyer would not be obliged to take it; that is to say, he could not be compelled to take it if it were a little better than the guarantee, any more than he could if it were a little worse. Hence the reasonableness of the trade meaning allowing the leeway stated. Gravel, sand, or trap-rock likewise varies because each is a natural product; the law in construing clauses applicable to them allows a certain leeway, backward and forward, which it would not allow in the case of a manufactured product, that can be made with at least practical uniformity.

There is another rule appertaining to the construction of contracts, which is perhaps more important than any of those to which reference has been made, though based on exactly the same principle. In later years it has been called the rule of "reasonable construction," which may be illustrated by three or four examples. Two of the earliest instances of the application of that rule in this State were the Borough of Homestead case, and the Queen Lane Reservoir case. Reference will be made to the latter case only. In that case, which is

known in the reports as Filbert vs. the city of Philadelphia, the contract provided for the construction of a reservoir according to certain plans and specifications, which were detailed at great length, as municipal specifications always are. It further provided that the reservoir should be a "complete and perfect reservoir, ready for use." When the reservoir was turned over to the city of Philadelphia, instead of being ready for use, it was found to leak badly, because underneath a part thereof there was a large quantity of micaceous rock. The city refused to pay because it was not a complete and perfect reservoir ready for use. But the court said that was not what the contract meant at all, but instead it meant that if, by a strict compliance with the plans and specifications, there could be produced a complete and perfect reservoir ready for use, the contractor must produce it; that he must not vary from the plans and specifications, because if he does he has not done the work which he contracts to do, and therefore cannot recover the contract price, even though he does thereby produce a reservoir which is ready for use. In that case the jury found that the work was done strictly according to the plans and specifications, and the contractor recovered the contract price, notwithstanding the leaky condition of the reservoir.

In the later case of Flintic Stone Co. vs. Mayor, etc., of New York, the contractor guaranteed that the reservoir would hold water; and in another case (Bush vs. Jones) in the Federal Court in this city, he guaranteed that water should not come into the building to be erected by him. In each of those cases the rule which has been stated was applied, notwithstanding the fact that the water leaked out in the one case and leaked in in the other, because the contractor had done exactly as he contracted to do, in building according to the plans and specifications.

In the cases thus given there was a seeming, if not an actual, conflict between the purpose to be attained and the actual clauses in the specifications; but the rule of reasonable construction applies even where there is no such conflict and the language used is plain in meaning. A single illustration must suffice. When the political break came in this city in 1905, there was a quantity of work being done on the filtration plants. One of the contracts was No. 25, which provided for the construction of fifty-five covered filters and a filtered water basin at Torresdale. The city, preliminarily to obtaining bids for the work, had certain borings made to show the character

of the underlying soil. The results thereof were shown to any one desiring to bid, but it was distinctly stated in the proposal that the city did not guarantee the result of those borings, and that the contractor had to take the responsibility for whatever was actually disclosed when the work was being done. It was further provided that if the reservoir, when excavated to the required depth, should show a soil unfit for a concrete bed, the contractor should, at his own expense, excavate that unfit soil, until a proper foundation was reached, and the additional excavation was to be filled in with concrete. The contractor in that case had a contract for nearly five million dollars. The filters and filtered water basin covered an area of about ten acres, and when it was actually excavated to the required depth, quicksand was found on one side thereof, covering, roughly speaking, four acres of ground. In order to ascertain how deep it was, the contractor forced down a gas pipe twenty feet long without finding bottom. It was estimated that to excavate down to a good foundation and fill in with concrete would have cost more than the entire contract price; and it was testified that to have done so would have made that place so rigid as to be injurious to the work. But there was no conflict in the specifications, which were clearly put and simple. The rule of reasonable construction was again applied, however; the engineers directed the contractor to excavate to a sufficient depth to fill in three separate and distinct layers of cobblestones and gravel, ram them until they made a reasonably solid foundation, and to put upon it the concrete. That direction was followed, but the special counsel for the city said it would not do, and the contractor should not be paid because he had not fulfilled his contract. It was held that while the city had not guaranteed that the earth at the foundation would be found to be satisfactory, there was an implied agreement that it would be found reasonably satisfactory for the purpose of the work, and that the above mentioned clauses which required additional excavation, and filling in with concrete if it were found not to be so, were intended to meet cases of comparatively speaking trivial defects in the underlying soil when the excavation took place. It was accordingly held that the contractor had a right to do what he did, and should be paid for his contract, and for the extra work in putting in the cobblestones and gravel; and that decision was right.

Of course, when plans and specifications for an engineering contract are considered, one must consider them like anything else. Subject

to the qualifications above stated, it is the meaning of the words used, and not the intention of the man who drafts the specifications, that is to be taken into account, for not otherwise can the minds of the parties meet in making their contract. Were it not so the owner might say that he understood the words to mean one thing, and the contractor, that he understood them to mean another. Under such circumstances, who could decide between them? Manifestly only the meaning of the words used. And just here is where the engineer who was draftsman of the specifications, and is now interpreter thereof, commonly gets into trouble. As draftsman he knows that he intended the specifications to mean a certain thing, and therefore as engineer he says they mean that thing. Therein lies his error, for he is deciding not what they do mean, but what he intended them to mean, and that is not interpretation of the specifications at all.

Some time ago a well-known lawyer of this city argued before the Supreme Court as to the meaning of a certain act of assembly. He said to the court: "Your Honors, I know what this act means because I drew it myself"; to which the Chief Justice replied: "That is the reason you do not know what it means; you know what you intended it to mean, but what it does mean you do not know."

In going over specifications perhaps time after time, errors are found the last time which it was thought did not exist. In such cases one reads what one has in mind should be there instead of what is actually there. That is the experience of every man who reads his own composition. It is the rule, therefore, the necessary rule, that the meaning of the words must govern the construction, for the man who contracts on the specifications has just as much right to say what he intended the meaning should be as the man who drew the contract.

During the last session of the Legislature, the present Attorney-General drafted and had passed an Act of Assembly (Act June 1, 1909, P. L. 381) which provided that all clauses in contracts providing for arbitration should be void, except where the contracts were made by corporations vested with the power of eminent domain. In all other cases, notwithstanding the arbitral provisions, the parties were referred to the law to determine their rights. It is a grave question whether that act is worth the paper it is printed on. In the first place, the courts have been very careful in sustaining the inherent independent right of a person *sui juris* to make such contracts as he pleases, so long as they do not interfere with some public policy

on the subject. In the second place, they have been careful also to say that no restrictions shall be put upon one class of men or contractors, and another class be free therefrom, unless there are very clear reasons indeed for the discrimination. In the present matter one is speaking in moderation in saying that it is difficult to understand why there should be a public policy which says that certain persons shall not contract that disputes shall be settled by a chosen engineer, and yet the Pennsylvania Railroad and the city of Philadelphia shall have that right. As a general rule, a public policy must be broad enough to embrace every matter within the circle of its influence, and the alleged one appearing in that act does not seem to be so, in view of the exception stated, and in view of the constant reiteration by our courts that such provisions are to be encouraged and not discouraged. Whether or not the act is valid, however, is not of much moment, and none whatever in this paper, because substantially all the great engineering constructions are under contracts with corporations vested with the right of eminent domain, viz., governments, States, municipalities, railroads, other public service corporations and the like, all of which exercise the right of eminent domain.

One of the difficulties not infrequently met with in the arbitration of contracts grows out of a state of affairs which is met with in many contracts, viz., the clause providing that if a difficulty arises it shall be submitted to three arbitrators, the party of the first part to select one arbitrator, the party of the second part to select the second, and the two arbitrators thus selected to choose the third. That seems simple enough in statement, but in fact it is not workable, for the man who is in the wrong commonly selects an arbitrator who always agrees with his contention, and never agrees to a third arbitrator, unless it is known in advance that the third man will do likewise. Hence the law says that unless the arbitrator is named, either by name or by reference to his office, so that he is designated beyond all question, the arbitral provision is void. The reason is that otherwise the provision intended to avoid strife will be productive of it, as well as of delay and wrong to the innocent party. If the designation of the arbitrator is made by naming his office, it does not mean the man in office at the time of the signing of the contract, but the man in office at the time the question for decision arises; and if he then starts to decide the questions at issue and is turned out of office, or refuses to proceed—as not infrequently happens in public contracts—that is the

end of the attempt at arbitration, because one cannot be forced to accept one of two arbitrators at the option of the opponent, when only one has been agreed upon, and the arbitration clause under such circumstances becomes absolutely valueless, and the parties are left to their actions at law. It is seen at once that this is correct, for otherwise the city might dismiss a competent arbitrator, and substitute in his place one found to be more complaisant, and thus the contractor be seriously wronged.

There is another thing which engineers, as arbitrators, attempt to do once in a while, which the law in no uncertain language says shall not be done, and it is this: It makes no difference how broad the arbitration clause may be, it may be as broad as language can make it, yet it cannot be stretched far enough to cover the errors of the arbitrator himself. If the engineer, who is acting as arbitrator, makes a blunder, he cannot settle that matter on the contractor by himself arbitrating it. The law will not permit the blunderer to thus wrong the contractor. The engineer must bear his own burdens, and the owner, whose agent he is, must, as between him and the contractor, bear those burdens because the engineer is his agent. So also these arbitral provisions will not be construed to cover any matter not clearly within their purview, for the reason that they forbid recourse to the ordinary courts of law to settle ordinary disputes, and that can only be done by a distinct provision to that effect.

Another thing that arbitrators sometimes forget is this: Before a single thing is done as arbitrator, one must give both sides reasonable notice of the time and place of hearing, and an opportunity to produce their evidence. If one of the parties then chooses to stay away, he is as much bound by the decision as the others who are present. But if no such opportunity to be heard is given, the decision amounts to nothing at all. The reason for that conclusion is obvious. At the root of all our jurisprudence, and as the basis of all our liberty, is the fact that no man shall be deprived of his life, liberty, or property without "due process of law," which always carries with it the opportunity to be heard before his rights are determined.

The right to be heard for the same reason applies to the usual provision in a contract which enables the owner to cancel the contract if the contractor does not proceed with his work in certain ways and at certain times, in accordance with certain notices which are required to be given to him. For illustration reference is again made to the filtration cases.

At the time of the political upheaval of 1905, there was in the office of Director of the Department of Public Works of this city an honest man—it may be thought strange, but it was so—and he was asked to cancel the filtration contracts without giving notice to the contractor. He refused to do it, and the result was that he was given to understand that his resignation would not be unacceptable. It was given and was accepted. Another director was appointed, and he canceled the contracts offhand. When he was asked whether or not it was true that he canceled those contracts without any notice to the contractor, and without even waiting until his signature on his oath of office was dry, he was compelled to admit it. The cancellation was set aside. Can one imagine any justice in taking away contracts for millions of dollars without giving the contractor an opportunity to be heard? No court would permit that, and it did not in that case, which resulted in a verdict against the city of Philadelphia for upwards of two million dollars.

There is another common clause in most contracts, providing that "no work shall be treated as additional or extra, unless it shall have been ordered in writing." To the great surprise of the arbitrating engineer, he not uncommonly finds that that is a provision which is capable of being waived by an oral agreement, just as much as any other provision, provided the waiver is clearly proved; and it should be so. If it were not so, then a clause which is inserted for the protection of the owner, instead of simply protecting him, would be wrested from its proper purpose to the injury of the contractor, and the law says that cannot be done. The engineer, if agent for the owner, may orally waive that provision just the same as the owner may, and the latter will be bound thereby. In all such cases the contractor may recover for his extra work, with the same effect as if it had been ordered in writing, and the arbitrating engineer is bound to give it to him.

Likewise there is generally a provision that the contract must be performed in accordance with its terms, which means simply substantial performance, a failure in comparatively unimportant details being held insufficient to defeat the contractor's right to be paid. On the other hand, a man who does not substantially perform a contract cannot recover anything, no matter how much work he does; unless the owner himself takes over the contract and completes it, and then the contractor recovers his contract price less what the owner has been compelled to pay to get it completed.

There is another common clause which says "all work must be

done to the approval and satisfaction of the engineer," and that has been a cause of much litigation. In some States it is held that if the contractor can satisfy a jury that he has completed his contract according to its terms, then that is the end of the provision requiring completion to the satisfaction of the engineer. That conclusion is grossly illogical, however, because under it the clause is an absolutely nugatory thing, and might as well have been omitted, for with it in or out the contractor could not recover unless he proved that he had substantially performed his contract according to its terms.

In the case of Singerly vs. Thayer, the judge of the Court of Common Pleas said that such a clause is fully complied with, if what the contractor did, should have satisfied the engineer. But surely that is not the test, and should not be, for it substitutes for the contractual provision that the engineer shall be satisfied, one that the jury shall be satisfied, to which the parties did not agree. The true rule must be the one that the contract provides for, viz., the contractor must satisfy the engineer that the work is done according to plans and specifications. This does not enable the engineer, through caprice or fraud or anything similar, to cheat the contractor. Under such circumstances, if the contractor can satisfy the court and jury that the engineer is satisfied, but simply refuses to express his satisfaction, or through any wrongful motive refuses to examine the work or to be satisfied with it, he (the contractor) can recover, just as he would if the engineer had expressed his satisfaction. Here again the law refuses to permit a protective clause to be wrested from its intended purpose to the injury of another.

There was another point which arose in the filtration case, which is met with from time to time. In that case several of the contracts provided that the work was to be finished in so many working days, and the question arose, What is the meaning of "working days"? Of course, those words may mean either every day except Sundays and holidays, or they may mean every day in which the particular work contracted can be done. In the law they sometimes mean one thing, and sometimes the other. In the unloading of vessels, for instance, where demurrage, wharfage, etc., are very expensive items, and the work can be done every day whether it rains or not, "working days" mean every day but Sundays and holidays. But in unloading salt, by the custom of that trade, they only mean days on which it is possible to unload without injury to the salt. So in the filtration

case the question arose what was meant by "working days." Of course, a large part of the work was done in the open. A reservoir cannot be concreted during a heavy rain. In that case the words were therefore construed to mean days in which that work could in fact be done. In constructing a tunnel, on the other hand, they would probably be construed to mean every day except Sundays and holidays.

There is usually also a provision in engineering contracts which says that if the work is not finished on or before a certain time, the contractor shall be charged so many dollars a day, or a week, or a month, as and for liquidated damages, and not as a penalty; and the question which arises is, What is meant by liquidated damages? Here again the law construes the thing to mean what it is in fact, and not what one may choose to name it. If it is not liquidated damages in fact, the court will not allow a recovery upon the theory that it is, simply because it is called so.

In the case of Clements vs. Schuylkill River East Side Railroad, when the railroad passed under Twenty-fifth Street, it was necessary to raise the grade of Callowhill Street, and also of the houses fronting on it, in order to avoid leaving a hole. Mr. Clements had a house fronting on Callowhill Street, which it was necessary to raise to the new level, and the Railroad Company agreed to raise it and have it finished within a certain time, agreeing that if the work was not completed by that time, the Company would pay him $150 per week, not as a penalty, but as liquidated damages for the delay. There was a delay of twenty-eight weeks, and Clements made a claim for $4200, though the house itself, when the work was all done, was worth only $3000, and rented for $25 a month. Clements' actual loss, therefore, was six months' rent, $150, yet his claim was for $4200, and the lower court allowed it. The Supreme Court said, however, that though it was called "liquidated damages," it was not that in law or fact, the provision being put in as a club over the head of the Railroad Company for the purpose of getting the work done within the time specified. So stated it was plainly only a penalty, and Clements was allowed to recover his actual loss, and no more.

There is another thing right in that connection which is usually lost sight of by the engineer when arbitrating contracts. If the delay in completion is caused by the engineer as agent of the owner, or by the owner himself—it makes no difference which—then, though the contract says no extra time shall be allowed unless it is agreed to in

writing during the progress of the work, it still must be allowed, though not asked for during the performance, because the owner will not be permitted to penalize the contractor for matters which are plainly the fault of the owner or engineer.

Another matter which arises once in a while, and in fact arose quite recently, is worthy of mention here. An engineer, who was the arbitrator in the case, met and heard both parties, and made an award in favor of the contractor for a certain amount of money. Afterward he thought he had made a mistake; he called the parties together again and made another and different award. The party who suffered by the change protested thereagainst. The question was: Had the engineer the right to correct his supposed mistake in that way? The court said he had not that right. The basis of the decision was that as the arbitrator is not learned in the law, and is more amenable to improper influences than the ordinary judicial officer is supposed to be, it might be productive of great abuse and wrong were he permitted to change his award after he had once announced it.

Many contracts provide that no suit shall be brought until after the final certificate is given. This provision is subject to restriction, however, for if the engineer, by caprice or for any arbitrary reason, refuses to grant the final certificate, the contractor may proceed at law to recover his claim with the same effect as if it had been issued. Again, the court says that it will not permit a provision made for the protection of the owner to be wrested from its legitimate purpose to the contractor's injury. That will not be allowed, under any circumstances.

Many contracts provide that no certificate except the final certificate shall be evidence of the fact that the work has been done in accordance with the plans and specifications. Under that clause the moment the final certificate is given, the character of the work cannot thereafter be challenged. It makes no difference how poorly it may turn out to have been done, or how many times it gets out of order. If that clause is in the contract, it conclusively and forever determines that the work was done according to the contract. It is very important that these contracts shall be changed in their wording in that regard, or that the engineer shall be particularly careful before he gives his final certificate. If it is necessary that the contractor shall have his final payment, the final certificate should be so worded as to leave the matter open for further investigation until it can

certainly be known whether or not the work has been properly done, otherwise the contractor will have an unassailable position, acquired perhaps by blinding the eyes of the arbitrator.

If the engineer, as arbitrator, wrongs the owner or contractor,—this does not mean if he makes a mistake, but if, in point of fact, he intentionally wrongs the owner or contractor,—then he is liable himself for any damage which accrues by reason of that wrong. No one will object to that rule of law. It should be so, and is so. If one does his duty to the best of his ability, no matter whether the ability is great or small, that ends the matter, and one is not liable. But if intentional wrong is in fact done, one is personally liable for whatever damage is done to the party wronged.

If what has been said has covered properly the subject under consideration, then the conclusion will follow that there is a law greater than all those referred to, and one which underlies and controls them all: that is the eternal law of righteousness. In the early days of mankind, during what may be termed the "rush-light period," the engineer had little or nothing to do; true, he was there in the inchoate, but as an engineer he was wholly unknown. In this age, commonly now called the "age of electricity," but which might just as aptly be called the "engineering age," when individuals are erecting high buildings, when corporations are constructing great bridges and tunnels, when municipalities are constructing aqueducts and filtration plants, and nations are building canals connecting the great oceans, the position of the engineer has reached a place of dignity and importance second to none; and the question is: How will he measure up to the importance of the position which he has acquired? The greatest of human lives have always been alike the most complex and the most simple. The most complex in their comprehensive knowledge of things, and the most simple in their dealings with their fellow-men. So also it must be with the engineer as it must be with every trade or profession which has reached the stage at which he has arrived. In drafting plans and specifications he must have the most comprehensive views, and must keep abreast of science as it expands and develops. But in interpreting and arbitrating, there is one single, simple rule laid down for his guidance, the greatest rule ever given to mankind, and that is the one which says "Do unto others"—to the owner and contractor alike—"as you would that others should do unto you." If engineers measure up to that rule, they will find little or no difficulty in interpreting or arbitrating contracts.

DISCUSSION.

W. C. Furber.—Mr. Simpson referred several times to the "engineer" as the "agent" of the owner. Some contracts, and in particular that form of contract known as the "uniform contract," which has the approval of the American Institute of Architects and National Association of Builders, declares in the preamble that the architect is the "agent" of the owner. I would like to have that clause defined, and know to what extent he is the agent of the owner, and to what extent that agency affects his power as an arbitrator.

Mr. Simpson.—The engineer, so long as he is superintendent of the work under his charge, is unquestionably the agent of the owner. But when he acts under the provisions in the contract which provide for arbitration, he ceases to be the agent of the owner, and occupies the semi-judicial position to which I have already referred. The engineer may be arbitrator at the end of the contract, with the same effect as if he had never been named as agent of the owner.

S. M. Swaab.—Civil engineering is defined in the charter of the Institute of Civil Engineers of Great Britain as "the art of directing the great sources of power in nature for the use and convenience of man." It must be noted that this definition, written by one of the pioneers in the art, considers it merely from a utilitarian point of view. We should therefore be very thankful to Mr. Simpson for mentioning the one all-important quality in his judgment which an engineer should possess, viz., righteousness.

Mr. Simpson has made clear some of the basic principles in law and equity as applied to the interpretations of engineering contracts and specifications, and when reduced to their lowest terms these principles seem to resolve themselves into the application of the principle of the square deal as applied through the medium of common sense to both parties to the contract. The speaker has shown, above all, that the engineer should possess the courage of his convictions, that he should not attempt to shift the responsibilities which are naturally his, on the contractor—the other party to the contract. Then, too, it sounds good to hear Mr. Simpson say that in his judgment engineers are generally righteous.

John C. Trautwine, Jr.—Criticism has been made of engineering books, on the ground that they make no mention of "righteousness"; but I should have thought it more remarkable if they had made such mention; for, in our profession, righteousness is taken for granted. And yet, we must remember that we are still enduring, to a great extent, the burdens of a so-called industrial "system" which puts a premium upon slickness—upon ability to out-do our fellow-man, which thus sets us all at one another's throats, and—if Mr. Simpson will pardon me—breeds the tribe of lawyers; and it is one of the beauties of this "system" that it creates all the difficulty we have been discussing, in the drawing-up of specifications and in the doing and inspection of work under them.

In drawing specifications, as Chief of the Bureau of Water, I followed the fashion and provided that all matters in dispute should be referred to "the engineer" (meaning myself), and that his decision should be final and binding. Now this makes of "the engineer" a little despot, and it has been said that there is no government like a despotism—provided you can get a good despot; but I confess it seemed to me that the contractor must have had strong faith in our

alleged "righteousness" when he thus put himself at the mercy of a man who depended for his bread and butter upon the other party to the contract.

Every one who has had much to do in the matter of stringing words together must have experienced the difficulty, which Mr. Simpson has emphasized, of making those elusive creatures of ours do what we want them to do; and the engineer must never be surprised if the court interprets a clause in his specification as meaning just the opposite of what he intended.

Mr. Simpson has mentioned the Queen Lane Reservoir case, in which the contractor had agreed to furnish the city with "a complete and perfect reservoir ready for use," and yet was given full payment by the court, in spite of his having furnished an incomplete and imperfect reservoir, unready for use (or rather no reservoir at all), the court holding that the contractor, having built according to the city's specification, could not be held for the completeness or perfection of the reservoir, or its readiness for use, whatever he might have agreed to do in this regard. In later specifications, and in the hope of obviating this difficulty, I inserted a clause in which the contractor stated that he had examined the city's specification, that he found the specification good and sufficient, and that he *therefore* agreed to furnish the city with "a complete and perfect," etc.

My recollection is that this benevolent purpose was thwarted by the city's legal advisers, on the ground that it would somehow be illegal to attempt to hold the contractor in this way; but I submit that a contractor, signing such a contract, simply accepts the city's specification *as his own*, and places himself in the same position as though he himself (instead of the engineer) had drawn up the specification, and the city had accepted it. My own lay impression of the matter is that even such a clause is unnecessary, and that the contractor, in signing the Queen Lane contract, did virtually accept the city's specification as his own, as though he had drawn it himself; and that his failure to furnish the "complete and perfect reservoir, ready for use," which he contracted to furnish, should have worked the forfeiture of the "retained percentage," instead of bringing him, under another corporate name, another $300,000 or so for making it into "a complete and perfect reservoir, ready for use," by means of an asphalt lining, subsequently added.

Mr. Simpson.—No. You can see at once where the thing would come out. If you have a contract with a man to build a reservoir of a certain size, and to hold water, he is bound to do that. If you contract with him according to certain plans and specifications for a reservoir that shall be water-tight, that will mean a reservoir to hold water, and if you find it will not hold water when the contractor is through with it, then it is the blunder of the engineer. If you say, in addition, that the contractor may make any changes necessary to make it a perfect reservoir, then of course he is bound to do it.

Dr. H. M. Chance—In drawing contracts of the forms in common use—I refer to those which have been well threshed out by different engineering organizations—the difficulty has been that the engineer anxious to put himself in a position where assumed rascality on the part of a contractor cannot injure his client, goes to extremes, and inserts provisions that cannot be enforced. In cases of disputes between contractors and corporations my sympathy, I must confess, is generally with the contractor, and not with the engineering profession.

The contract has usually been drawn by the corporation's attorneys, and most of its provisions are for the protection of the corporation, and few, if any, for the protection of the contractors. If a dozen contractors bid on a piece of work, the chances are that about nine of these will bid prices at which the work can be done at a profit; perhaps three or four will bid prices which are exorbitant, or possibly the three or four will bid prices that are less than the actual cost of the work. As engineers, we consider we are doing right in advising our clients to accept the lowest bid, provided the bidder is responsible and experienced. In so doing we take what may be considered an unfair advantage of the contractor. Through his ignorance, or lack of judgment, he has named a price which will involve him in loss. It seems to me that if this primary advantage has been taken, the engineer should be generous in his treatment of the contractor during the execution of the work. Under such circumstances it seems to me that every specification of the contract should be construed by the engineer favorably to the contractor, rather than to his employer. That is necessary if justice is to be done. But that is an impossible condition, for the engineer, paid by his employer to look after his interests, must always feel that he must construe the provisions of the contract literally. Engineering contracts are usually entirely too stringent. The contractor has no voice in what shall be done. His judgment is entirely ignored in the carrying out of the work, but if trouble is afterward found with the work he is made responsible for it. Mr. Simpson has mentioned a case in point, the storage reservoir which was built with an insufficient thickness of clay puddle to hold water. The contractor was not responsible for that.

The provision for doing extra work without pay as provided by many contracts can rarely be enforced. I do not believe engineers should countenance provisions of that kind. The contractor should be paid the cost of extra work he does, with a fair profit for his time, labor, and experience. In some cases these provisions for extra work are believed to have been inserted to limit the number of bidders, and engineers with no such purpose in mind have innocently copied these provisions and thus given them the mark of their approval. I have seen contracts that no intelligent man would sign, contracts compelling the contractor to do an indefinite quantity of extra work without pay, and on which no man in his senses would dare bid. And these contract forms are in some cases still used by engineers as a basis on which to build other contracts. Without knowing what mischief they can make, they use them as copy for the drafting of new contracts, and in this way these forms are perpetuated.

NOTES ON EUROPEAN WORKS FOR WATER-SUPPLIES, SEWAGE DISPOSAL, AND REFUSE DESTRUCTION.

RUDOLPH HERING.
(Active Member.)

An Address given December 17, 1910.

As the European cities are older than ours, and as their population is more concentrated, many questions pertaining to municipal engineering have developed rather faster and farther in Europe than here, and therefore European cities are very attractive for the municipal engineer to visit and to study. I have myself visited those cities a number of times to watch their progress. In some respects I think we are now getting quite close to their practice, and possibly in the future we may ourselves become the leaders.

On my last trip two American engineers traveled with me, Prof. F. S. Bass, of the University of Minnesota, formerly an assistant of my firm, and Mr. Charles Saville, an assistant engineer of the Massachusetts State Board of Health. These two gentlemen were anxious to visit European municipalities, and very kindly took notes and photographs for me, some of which I will show you later.

In the short time at my disposal I thought I would limit myself to what I found most interesting in their works for water-supplies, sewage disposal, and refuse destruction.

Water-supply.

On the continent of Europe ground-water or spring-water supplies for municipalities stand in the foreground. Physicians have insisted that the human element should not be relied upon in such an important matter as water-supply, and are therefore not favorably disposed toward filtration, but advise that water beneath the ground, or spring-water as furnished by nature, should be the sources of supply, and thus do away with the uncertainties of water treatment and management.

In the northern parts of Europe, usually covered with diluvial formations, which are often gravelly and sandy, because this territory was formerly covered by the ice cap, we find the ground-waters very plentiful.

European per capita water consumption is not as great as ours, and therefore the ground supplies more often suffice than here. In England this glacial deposit does not exist; and we find comparatively little gravel and sand, and, therefore, the ground-water supplies are comparatively rare.

In the northern parts of our country we may in the future be able to utilize many such supplies, and especially along the Pacific coast, where the western slopes of the Sierra Nevada will furnish magnificent ground-water supplies.

The continent of Europe has developed the engineering features of ground-water practice probably more than has been done anywhere else, by careful examinations and gagings to establish theories of underground flow, according to which one can figure pretty closely how much water may be obtained from these subterranean sources. To do this you must, by means of borings, ascertain the natural watershed of the ground-water, just as you would require it for surface-water. When the watershed is approximately located, the average rainfall is observed for dry years and the water-slope from the upper to the lower part of the watershed is ascertained. You can therefore pretty closely approximate how much water flows down and how much of it you can get. The wells from which the water is drawn have been placed parallel with the flow of water and also at right angles to it. Local conditions will indicate to the experienced engineer which plan will be the better one. It is usually the former.

Notwithstanding the existence of a good filtered water-supply in Hamburg, the medical profession did not like it, and urged its abolition and the substitution of ground-water, but the investigations proved that there was not enough ground-water to completely take the place of the river-water. Then they concluded to use a mixed supply.

Ground-water, as compared with river-water, always has a cooler temperature in summer and a warmer one in winter. By mixing the two supplies, they get a more even temperature throughout the year. They hardly ever use ice for cooling water in summer.

In the sandy countries of northern Germany the ground-water generally carries with it iron in solution. Deferrization processes are therefore very commonly used.

It was also interesting to study the question of the ownership of these ground-water supplies, because a great deal of trouble has arisen on account of the law governing them. The old English law gives you

the ownership of all the water on your property. Therefore if you put in a pump, you can pump out all the water that comes. The engineer knows that that water comes from a more or less extended watershed, and when you pump the water out, some one else owning land lower down the watershed will be minus some water. On this account there has been a great deal of trouble.

It seems to me that the engineer should have but one view regarding this matter, and I think that the artificial laws now generally controlling the use of underground water-flows will be gradually displaced by the natural laws governing flowing water. That is, laws which apply to surface-water should apply also to ground-water flows.

No one is allowed to take water from a surface stream without compensating owners below for the amount of water taken from it. In America we generally have to compensate by paying for it in money. In Europe they compensate in kind. That is, they build storage reservoirs and supply the stream during dry weather with the amount of water that is being diverted.

Ground-water, as you know, is formed by the rain-water percolating into the soil to the water-table, where it flows gradually to some outlet at an open water-course, lake or ocean. All of our rivers are supplied in that way during the dry season. The Colorado River flows continuously, although it does not rain near it for perhaps nine months in the year. A portion of the rain-water percolates into the ground and flows unexposed to air and evaporation for long distances, and finally emerges and forms the river in the dry season.

If the ownership of ground-water should be controlled by the same principles as the ownership of surface-water, then the party owning the riparian rights has the use of all the water from the watershed naturally passing his property, and any one taking away water above must compensate all the riparian owners lower down. Thus, if you own a strip of land across the valley at the mouth of a river, you own all the water of that stream, and no one should divert any of it above, without paying for any loss caused by such diversion.

This view has been taken in Europe in the case of mineral springs. A mineral spring, as you can readily see, if its water is abstracted somewhere along its flow, is depreciated at its outlet. In Europe no one is allowed to make any borings within a certain distance of mineral springs, so that these cannot be depreciated, but will remain in their natural condition of purity.

A few years ago we heard a good deal about what was called the

"Breslau calamity." As the subject was interesting to me, I went to Breslau last summer to make a study of the conditions. Breslau has nearly half a million inhabitants, and is situated on the River Oder in the eastern part of Germany. It had a filtered river-water supply, and as the medical authorities thought the river-water was not sufficiently good, they wanted a ground-water supply substituted. It was done, and after about eighteen months this calamity occurred: Suddenly the water became undrinkable. It had a yellowish, brownish color, and a very disagreeable taste. A number of engineers and chemists were employed to study the causes of this change.

The water-supply was about 30 gallons per head—rather small when compared with American supplies. In 1893 the filters began to be insufficient in size, on account of the growth of the city, which had then nearly a quarter of a million inhabitants; and the water was rushed through the filters at high rates, so that the bacteria in the effluent were very numerous—about 2000 per cubic centimeter. The ground-water supply was finally installed in 1904, and came from a drainage area 3 to 4 kilometers wide and 10 to 12 kilometers long and having water-bearing strata 12 meters deep. A part of the area from which the water was taken was flooded occasionally by high water in the river Oder.

The "calamity" was caused primarily by overdraining and exhausting the natural drainage area. The water-table was greatly lowered, and that naturally caused the diluvial strata to become drained. Then the flooding of the land by the river-water above these strata caused a more rapid percolation through them than ordinarily, and in so doing dissolved the iron oxid and manganese deposited in the strata to such an extent that when the percolating water came down to the ground-water level it suddenly polluted it.

The following are the conclusions of the gentlemen who made the investigation:

1. In the upper humus clays or loam, by the effect of sulphuretted hydrogen upon iron ore, iron sulphids were formed in large quantities.

2. By the artificial lowering of the water-table these insoluble sulphids came in contact with air and were oxidized to sulphates. These and their further product, sulphuric acid, remained in the upper drier layer.

3. When high water penetrated the soil the sulphates of iron were dissolved. Sulphuric acid was taken up and both changed the superoxid of manganese contained in the soil to sulphate of manganese.

4. The flood-water while percolating and taking up a strong solution of iron and manganese, mixed with the ground-water, polluted it, and was drawn into the cities' reservoirs.

The present is a mixed ground-water and filtered river-water supply in the proportion of 1 to 3.

In England they believe in long-time storage of water, whereas here and in Germany short storage is preferred, say a few days, while in England it is months. We first purify the water and then store it in quantities merely sufficient to compensate for the fluctuating drafts of water within a few days. In England they store for sedimentation, and believe that long storage purifies water. One of the greatest authorities, Professor Houston, has made some extensive experiments in this connection and advocates sedimentation, bacterially speaking, as being almost as effective as filtration. He has found that the bacteria settle out in some cases as completely as they have been removed in filters. Personally I do not quite agree with the conclusion, because of the seasonal "overturning" in many reservoirs.

Another question attracted my attention and related to the removal of bacteria from potable water. If any analysis shows many bacteria, we say it is bad water. In sewer purification the bacteria are the most useful assistant the engineer can have to help him. But we must discriminate between bacteria and bacteria. Some are pathogenic and cause disease. We must destroy these if we know how. But the other bacteria are most useful in decomposing dead organic matter and must be cultivated.

The destruction of the pathogenic bacteria will give us something to do in the future. We have made some progress in this country in that direction, so far as water purification is concerned. Hypochlorite of lime has been found efficient in economical quantities to destroy all the gas-producing bacteria, among which the pathogenic bacteria may be classed, while many of the hardy and useful bacteria may escape destruction. This fact was demonstrated a few years ago at Boonton, N. J., and I believe there are now over eighty cities using hypochlorite treatment to protect their water-supplies.

Sewage Disposal.

England is the best place to study this question. The rainfall is only one-half to three-fourths of what it is here. Therefore the rivers are correspondingly smaller. The population is large, and

there is a good deal of manufacturing waste and strong pollution of the rivers. Therefore England was brought to the consideration of this sewage disposal question before any other country. The English sanitarians have tried almost every possible method of purifying sewage. The first satisfactory method was suggested by Sir Edward Frankland, a prominent chemist of England, and Mr. Bailey Denton, an agricultural engineer. They found if sewage was put on a bed of porous sand about six feet deep it percolated through the same and came out pure. At that time nothing was known about bacteria, but since then the Massachusetts State Board of Health made its classic investigations of these so-called intermittent filters, and have set forth the reasons for the purification, so that engineers can design filters with assurance of efficiency and economy. If you give sewage a preliminary sedimentation, you can purify more than 50,000 gallons a day on one acre of sand. In England sand is scarce, so they tried to precipitate the suspended matter by means of chemicals, and there are about fifty patents for such processes. But the offensive matter is not only the solids which you take out. The dissolved organic matter also soon begins to putrefy after it is discharged, and again is liable to contaminate the rivers. The suspended matter accumulated at the bottom of the precipitation tanks as sludge and was extremely foul. All sorts of means for disinfecting it were tried, by treating it with lime, charcoal, etc. But the results were mostly disappointing.

The next idea was brought out by Dr. Travis, a resident of Hampton, south of London. He separated the liquids from the solids while the sewage was flowing through tanks. The liquids were purified in contact beds and the solids were kept separated and left to themselves until removed as sludge. He succeeded to a certain extent in bettering the conditions, but his sludge was still foul.

There is a district in Germany drained by the river Emscher where the city of Essen and many other manufacturing cities are located, containing together about two million people. When that district required its sewage to be purified, they appointed a commission and sent an engineer to England to study the question. The engineer was most pleased with the Hampton device and experimented with it at Essen. It would not answer their purpose completely because the sludge still remained foul. By a little further experimenting they found a method, an invention of Dr. K. Imhoff, by which the sludge became entirely inoffensive. After thirty years of trial, both in this

country and in Europe, I think we have at last secured a means which is hopeful for properly disposing of this sludge. At first the permanent success of this method was doubted in both America and Europe, but a visit to Germany last summer, where about twenty-five of these plants had been built and operated, convinced me that real progress had been made.

The whole sewage question should be decided along two lines. One is the effect upon health, and the other is the prevention of a nuisance. When it is a question of health, we must see to it that all pathogenic germs are destroyed. This is being done in several cities of Germany along the large rivers by putting hypochlorite of lime into the sewage after it has been screened and partly settled whenever an epidemic is reported in the town.

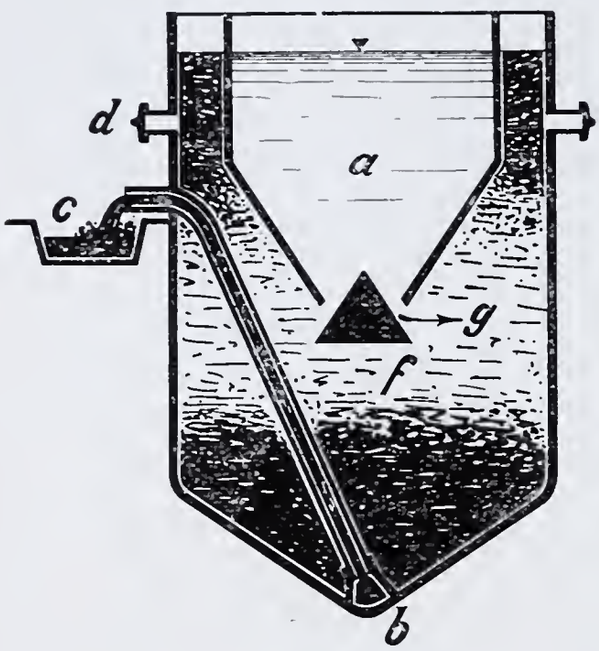


Fig. 1.—Imhoff tank.

When it is a question of nuisance, the treatment becomes more serious and costs more money. I believe we can now prevent all nuisances by an Imhoff sludge treatment and by oxidation of the liquid after it has been relieved of the sludge.

Fig. 1 is a diagrammatic sketch of the Imhoff sludge-separating tank. The sewage flows perpendicular to the plane of the drawing through the upper chamber (*a*) at a velocity allowing about two hours for sedimentation. The suspended matter settles and slides down the inclined bottom to a slot (*g*), through which it drops into the lower chamber (*f*). If the sewage is fresh when arriving at the tank, it is practically free from odor when leaving it. The present and most advanced idea in Europe is that the sewage must be kept as fresh as possible until it is finally disposed of. The suspended matter accumulates in the lower chamber and forms the sludge. It stays there from three to five months, and is then sufficiently "rotted out" to have no more offensive odor. In order to get this result there must be no circulation of fresh sewage in the lower tank; the sludge must be withdrawn at the bottom in small quantities at frequent intervals. This is done by opening a valve (not shown in cut) to the right of c and

FIG. 2.—Sludge which has been lying in the beds for three days and is ready to be removed by spading.

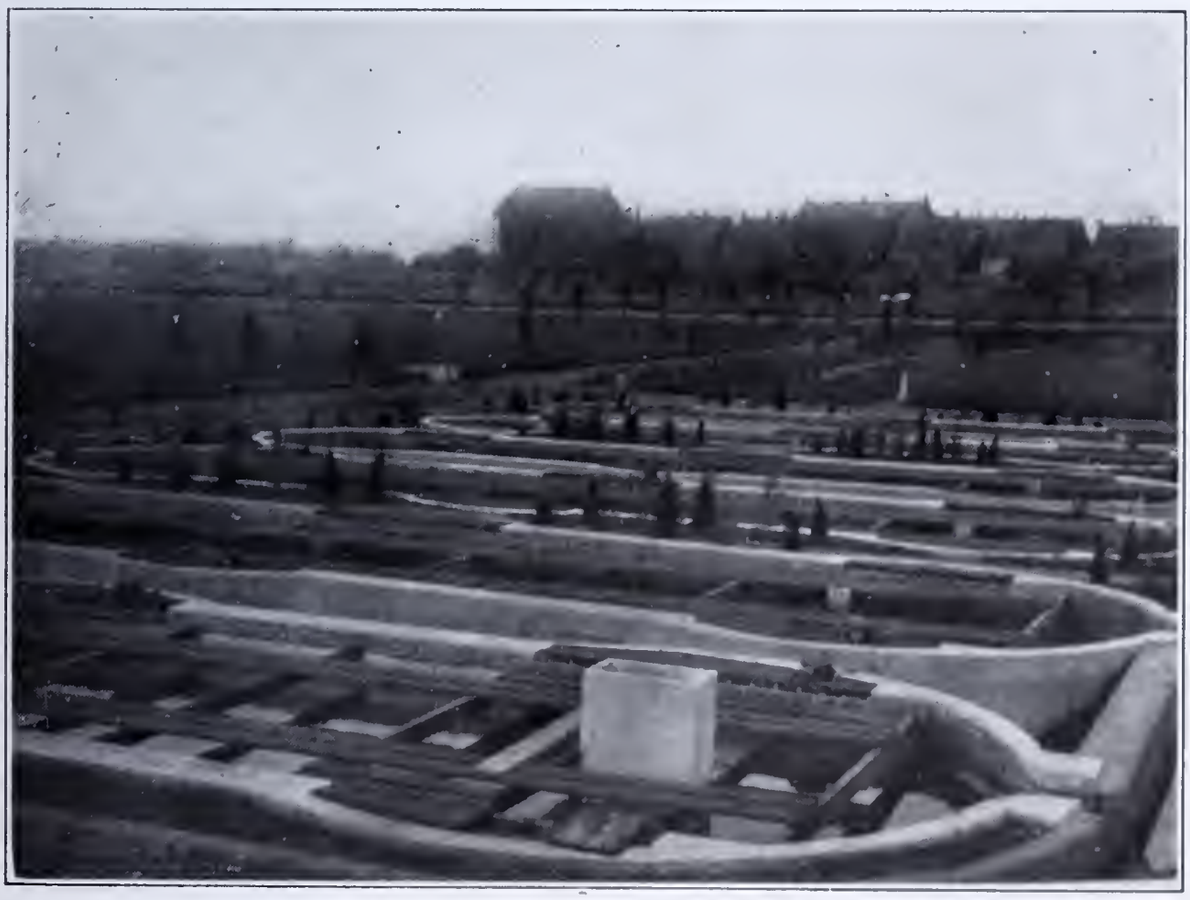


FIG. 3.—Imhoff tanks at Bochum, Germany.

the sludge will flow out and rise up in this pipe (*b*, *c*) to within about four feet of the water level in the tank. The frequent motion causes more thorough bacterial activity, which may be further hastened by the admission of fresh water under pressure near the bottom, to stir up the mass. The constant rising of bubbles also keeps the mass from compacting. The gases are chiefly marsh-gas and carbon monoxid, and therefore have no odor. Sulphureted hydrogen does not seem to develop to an objectionable degree, if at all. The sludge when withdrawn after a proper time has no

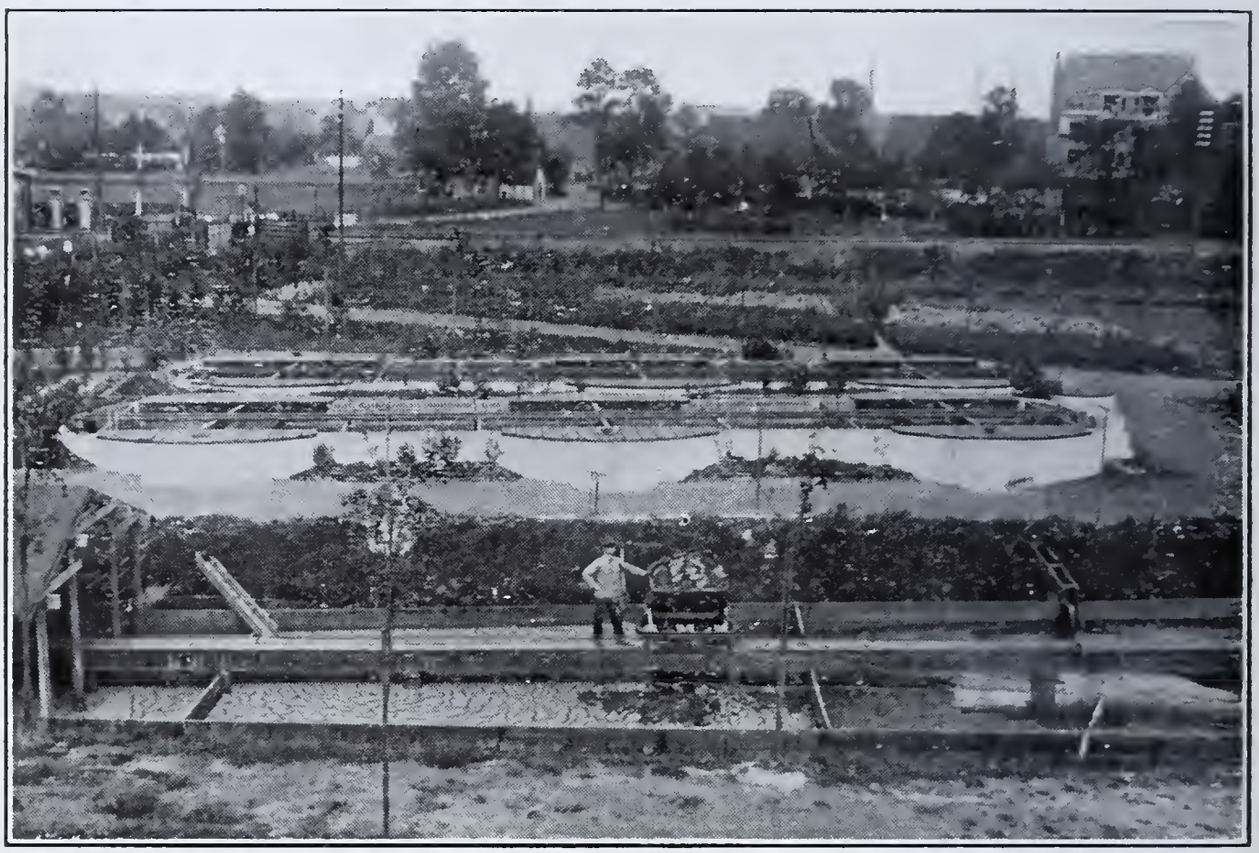


Fig. 4.—Imhoff tanks at Recklinghausen, near Essen, with sludge-drying beds in the foreground.

bad odor. The rising bubbles bring some of the light and fatty particles to the surface, forming a scum which also is not offensive and is separately removed at (*d*).

Refuse Destruction.

Formerly the destruction of refuse was mostly in the hands of the boards of health, but lately it has come into the hands of the municipal engineer.

Here again we find that England has been ahead of us. More than

forty years ago they started to burn this material, and today nearly all of the English cities burn all their refuse in high-temperature furnaces. In a few cities of France, Belgium, and Germany they are likewise using this method. Rotterdam is now building a large plant of this kind. There is no odor from these high-temperature furnaces. The fires must be so arranged and the mixture must be such that the temperature is at least 1200 or 1300 degrees Fahrenheit, and generally averages 1500 degrees, at which temperature the offensive matter is completely destroyed, and practically nothing is left but carbon dioxid and monoxid, which come out of the chimney, and nothing but clinkers and ashes are left on the grates. The high temperature produces steam, which pays for about half the cost of the destruction. All the refuse is burned without any nuisance being created.

SEWAGE PURIFICATION WORKS OF THE CITY OF PHILADELPHIA—PENNYPACK CREEK SECTION.

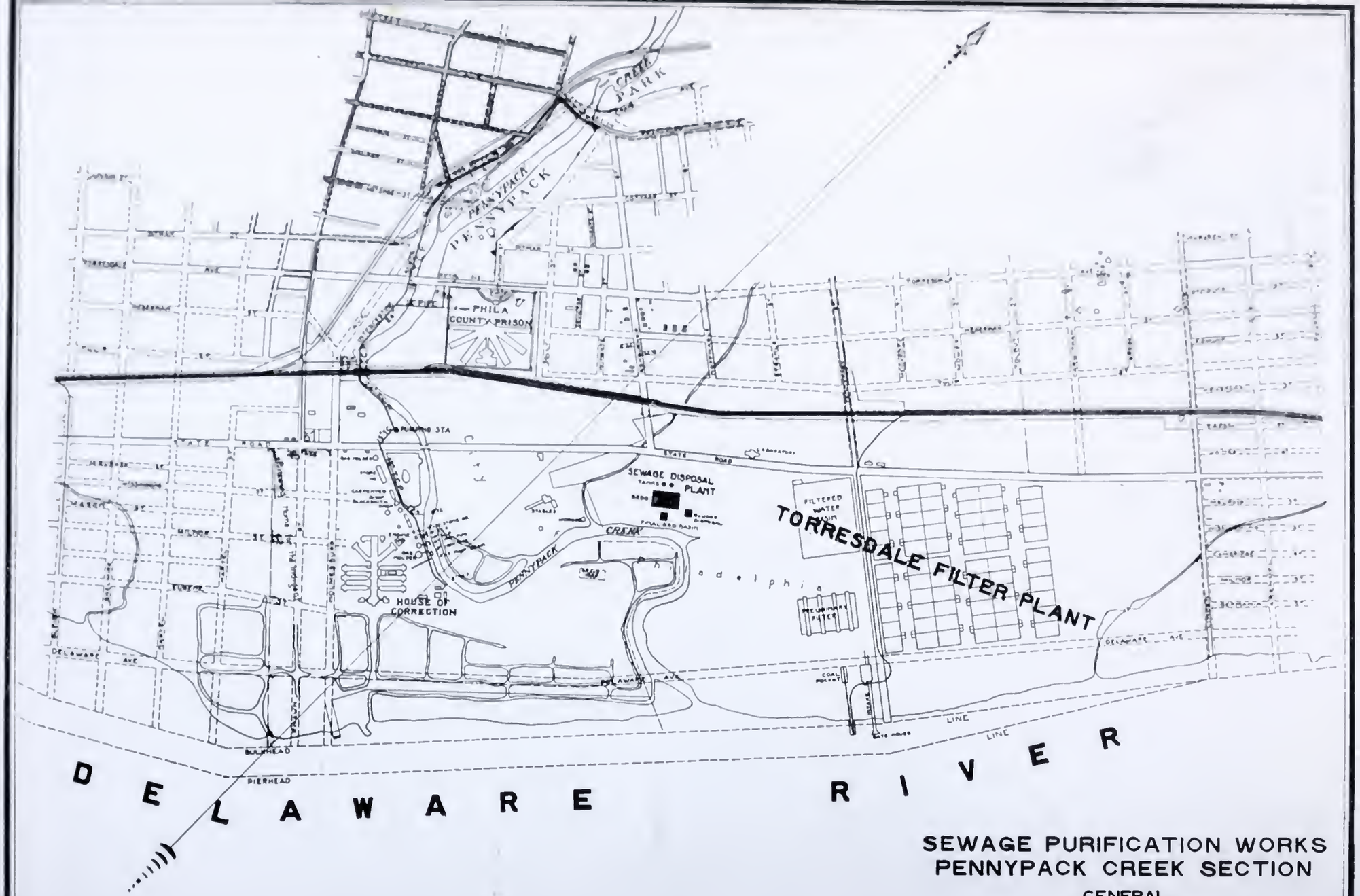
GEORGE S. WEBSTER.
(Active Member.)

An Address given December 17, 1910.

As part of the work of treating the sewage of the city of Philadelphia a disposal plant is now being constructed near Holmesburg adjacent to the mouth of the Pennypack Creek in the northwestern part of the city, and in close proximity to the intake of the Torresdale filter plant on the Delaware River, where approximately 240,000,000 gallons of water is filtered daily; this is probably the largest amount purified at any one station in the world. There is a tidal range in the Delaware River at this point of about five feet, which is sufficient to carry the sewage, after it has emptied from the creek into the river, up-stream as far as the intake of the filter plant. It is, therefore, important that the sewage which enters the Delaware River from the creek should be treated.

The city of Philadelphia owns the entire property along the river front from about 1000 feet below the House of Correction to Linden Avenue, a distance of approximately two miles, and from the Delaware River to the New York Division of the Pennsylvania Railroad, and no dwelling is at present located closer than about 2000 feet of the sewage disposal works. Also, the city has placed on its plans for park purposes the entire valley of the Pennypack Creek from the river to the county line, a distance of six miles, so that in the near future this valley will be a beautiful park, a large portion having already been purchased for that purpose.

Pennypack Creek extends about fourteen miles through three counties, and on its banks are villages like Rockledge, Hatboro, and Willow Grove. On Fig. 1 the conditions near the mouth of the creek are shown, where there are two penal institutions, the Philadelphia County Prison and the House of Correction, each containing a population from 2000 to 2500. The city has also recently purchased ground immediately adjacent, where it is intended to erect a home for the indigent which will accommodate a like number of inmates. The village of Holmesburg, near by, has a population of approxi-



SEWAGE PURIFICATION WORKS
PENNYPACK CREEK SECTION
GENERAL
LOCATION PLAN

AUTHORIZED BY ORDINANCES OF COUNCILS, APPROVED MAY 10, & JULY 5 1907

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS

Scale
1 in = 500 ft

Geo. E. Salomon
Principal Assistant Engineer

Approved April 6 1908
E. G. Wilster
Chief Engineer

Approved June 27
Geo. R. Stearns
Director, Department of Public Works

Fig. 1

mately 2500. There will, therefore, shortly be sewage from 10,000 people entering Pennypack Creek and discharging into the Delaware River a few hundred feet from the intake of the Torresdale waterworks. At the present time there are a number of sewers of the combined system discharging into the creek. The dry-weather flow of these and all future sewers will be collected by an intercepting sewer now being built along the banks of the creek and conveyed to a pumping station north of State Road and Holmesburg Avenue. The interceptors are so designed that they will collect the first flush of a rainfall and the excess storm-water will be discharged into the creek.

A force main extends along State Road to the disposal works near Ashburner Street, the general plan of which is shown in Fig. 1. The sewage from the force main enters two sedimentation tanks; these tanks are of the Imhoff type, somewhat similar to the one described by Mr. Hering (on page 132); they are also designated as Emscher tanks, because they originated in the Emscher district of southwestern Germany. These names are used somewhat indiscriminately, but refer to the same type of tank. At the Pennypack Creek sewage disposal works each Emscher tank will be 30 feet inside diameter and 32½ feet deep from the outlet weir to the lowest point of the sludge chamber and will project about 12 feet above the ground. The earth embankments will be carried to the top of the tanks and planted with trees and shrubs, so that the works will not be visible from State Road.

From the Emscher tanks the sewage passes to a dosing or equalizing tank, and thence to the percolating filters or bacteria beds. In England these beds are called percolating filters; in Germany, bacteria beds; and in America, sprinkling filters. These percolating filters, shown in Figs. 2 and 7, are about one acre in area, and are divided into five sections, or bays, so that any portion can be rested or repaired without by-passing the sewage. The media in the beds will be 6 feet deep and be composed of hard stone from 1 inch to 3 inches in size. The effluent of these filters will be settled in a shallow basin, where provision is made for disinfection with calcium hypochlorite either at the inlet end or as the effluent finally passes into the creek.

A pipe extends eastward from the Emscher tanks to a sludge bed composed of sand underdrained with tile, so that every opportunity will be given for the moisture to drain from the sludge. Fig. 3 shows the general type of Emscher tank adopted. Two methods of

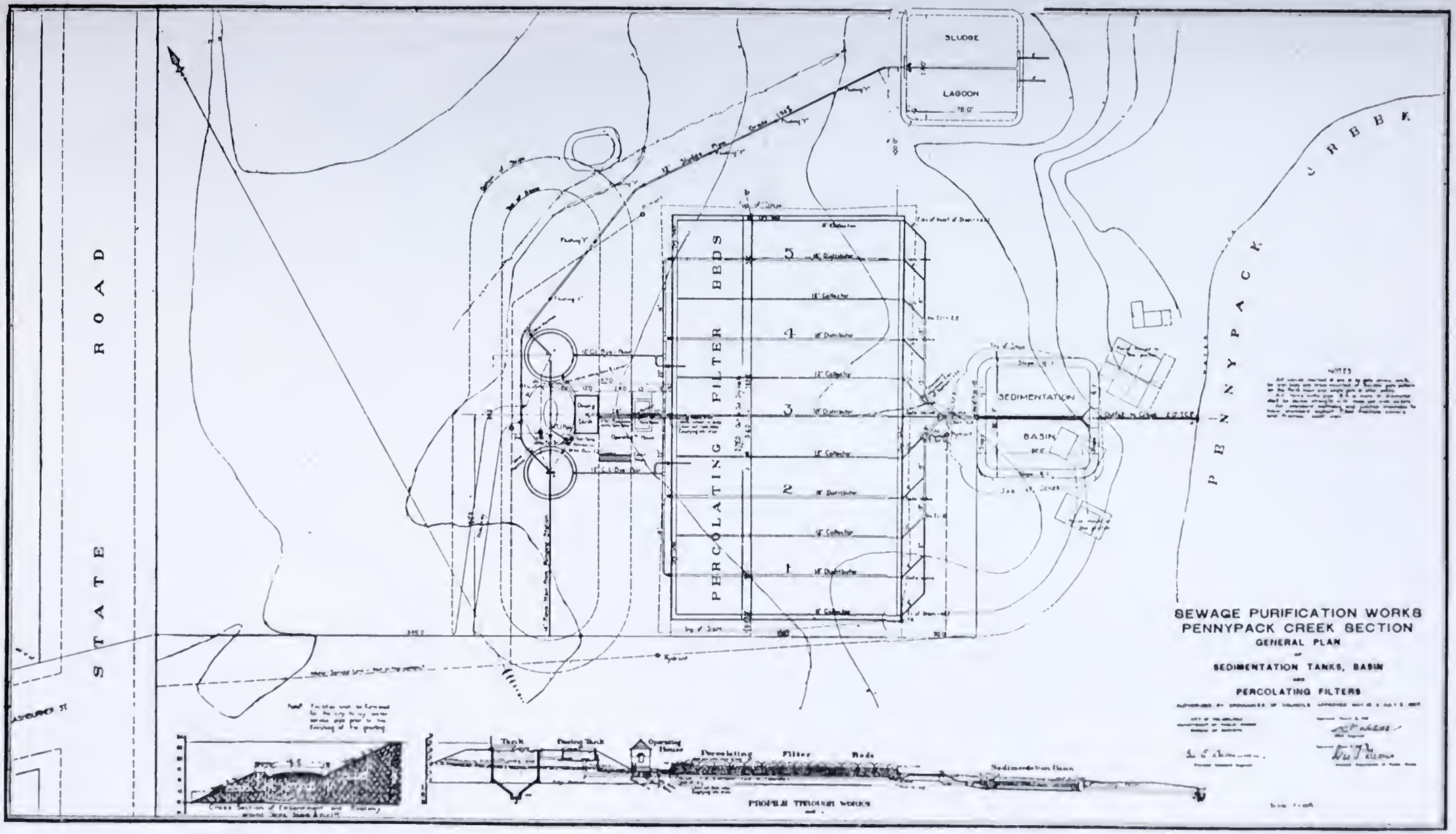

SLUDGE
LAGOON
STATE ROAD
PERCOLATING FILTER BEDS
SEDIMENTATION
BASIN
PENNYPACK CREEK
SEWAGE PURIFICATION WORKS
PENNYPACK CREEK SECTION
GENERAL PLAN
SEDIMENTATION TANKS, BASIN
AND
PERCOLATING FILTERS

FIG. 2.

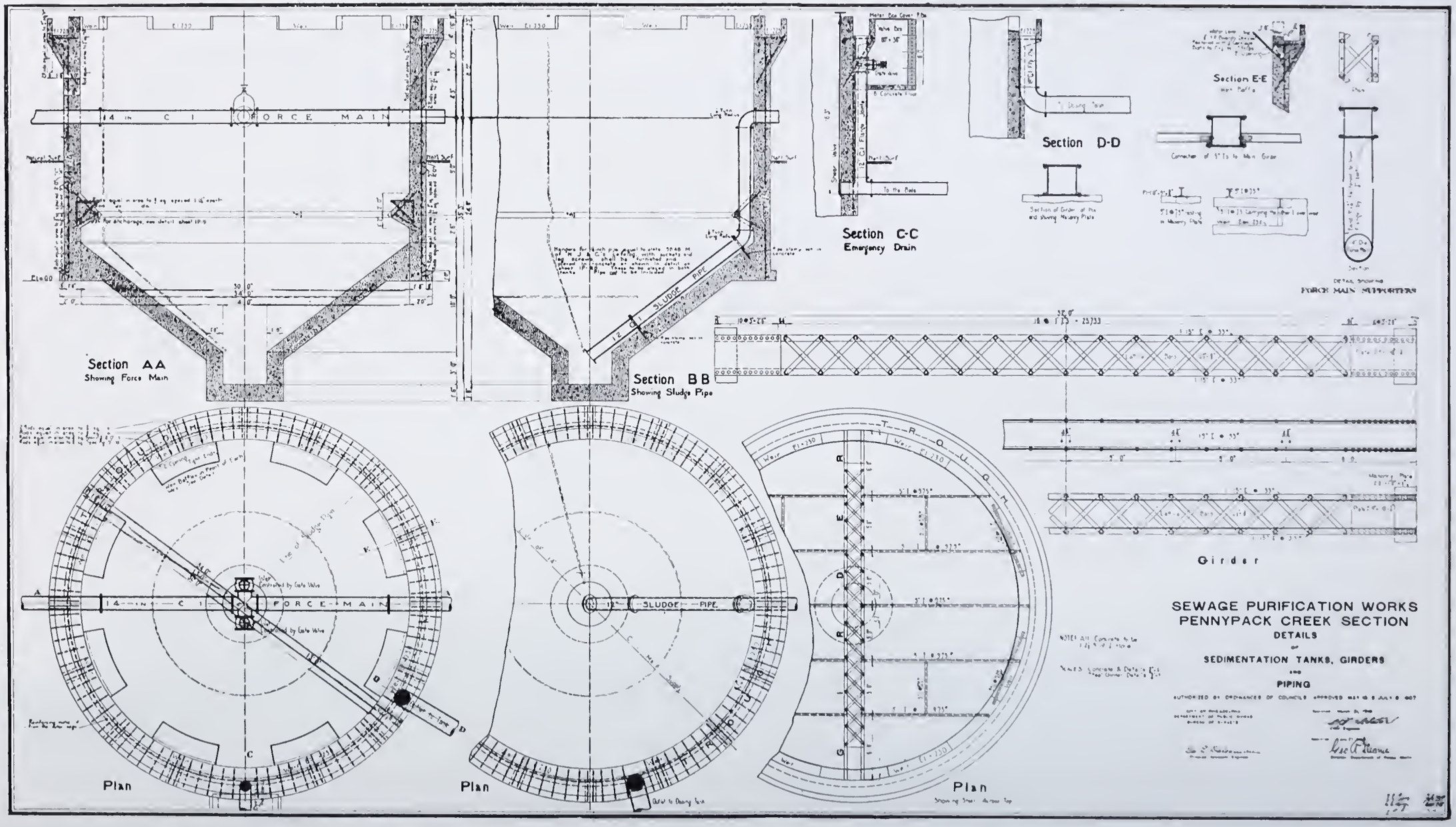

Section AA
Showing Force Main
Section BB
Showing Sludge Pipe
Section C-C
Emergency Drain
Section D-D
Section E-E
Girder
Plan
Plan
Plan
SEWAGE PURIFICATION WORKS
PENNYPACK CREEK SECTION
DETAILS
OF
SEDIMENTATION TANKS, GIRDERS
AND
PIPING

Fig. 3.

construction are to be used for separating the flowing sewage from the sludge chamber. In Fig. 4 a radial and vertical flow type is shown; in this case the force main sewage enters by a weir at the top, flows out and under a circular baffle, then rises and passes over the circumferential weir. The solids settle down into the lower or sludge chamber, where, after digestion, the sludge is removed by the hydro-

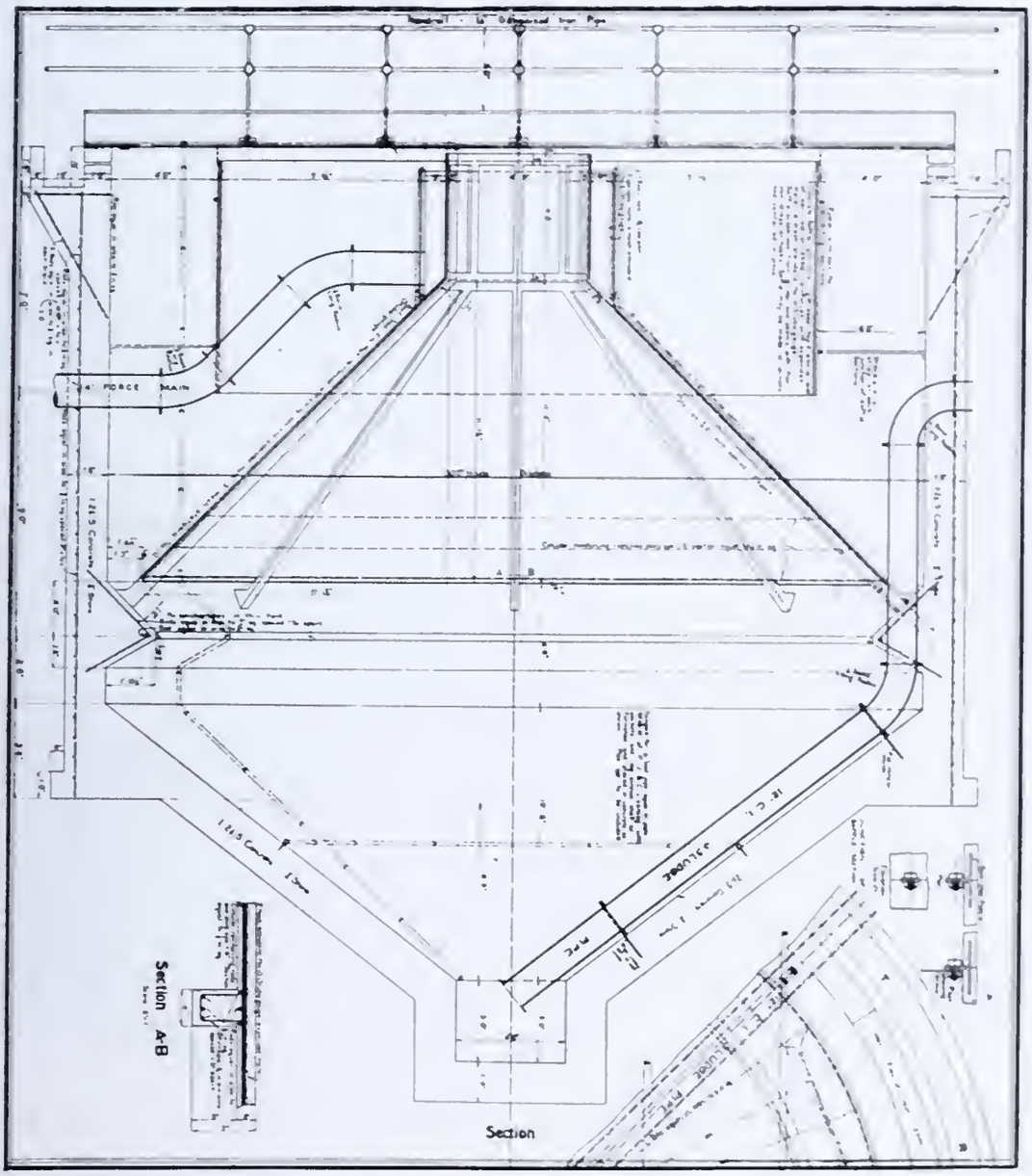


Fig. 4.

static head in the tank through the pipe shown in Figs. 3 and 4 to the sludge bed.

The experiments made at the Spring Garden testing station showed that judicious baffling added very largely to the efficiency of sedimentation; therefore the construction shown in Fig. 5 was designed. In this case the roof of the sludge chamber is of galvanized iron,

forming a series of concentric ridges and valleys; the sewage enters the basin at the center and is compelled to flow up and down by means of the four concentric baffles so placed that the velocity of the sewage as it rises is much less than when it descends. In the valleys of the roof are openings through which the settled solids fall into the sludge chamber; the tanks are so designed that the bubbles of gas rising from the sludge are deflected toward the ventilators and prevented from passing through the fresh sewage in the settling chambers.

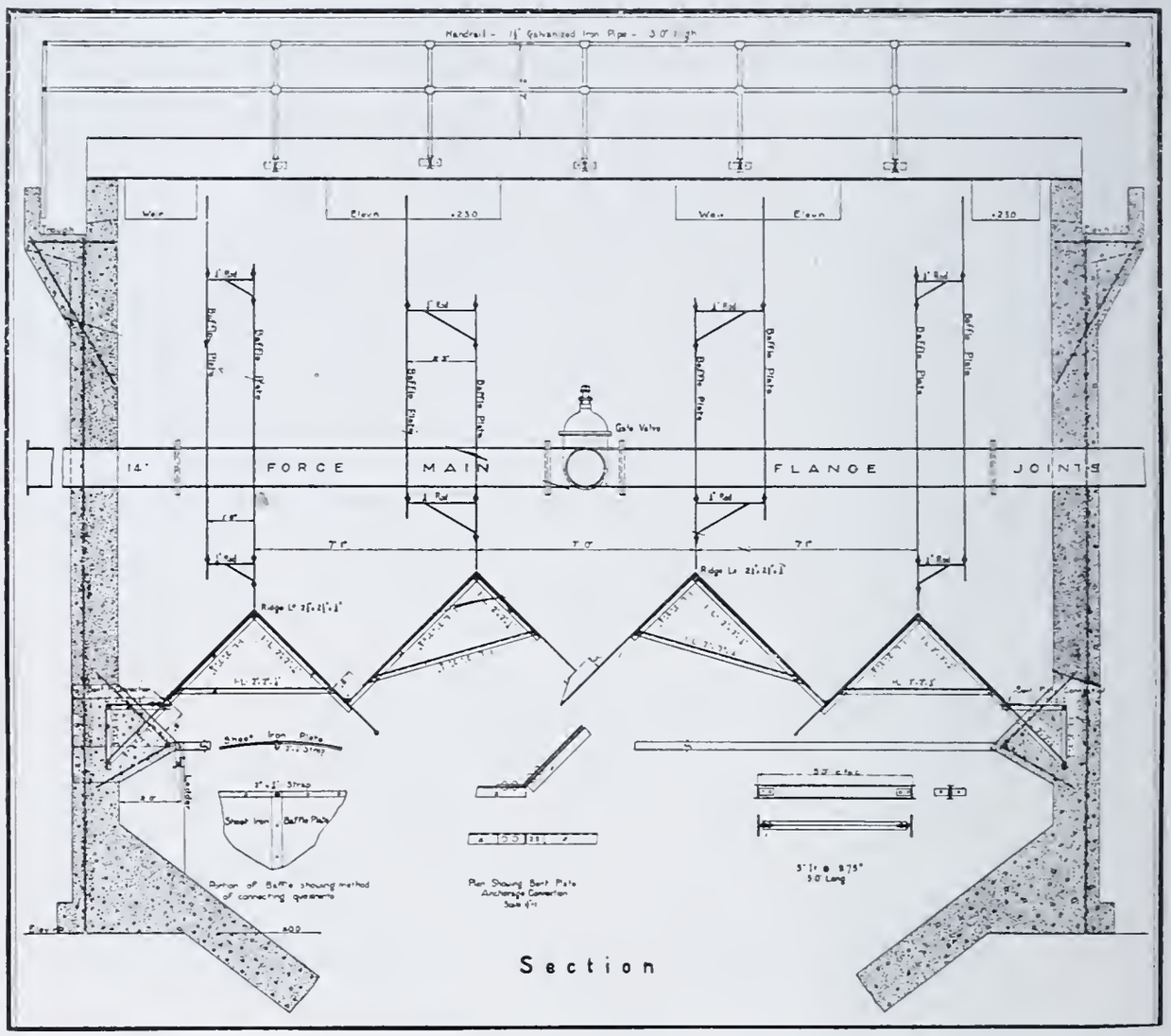
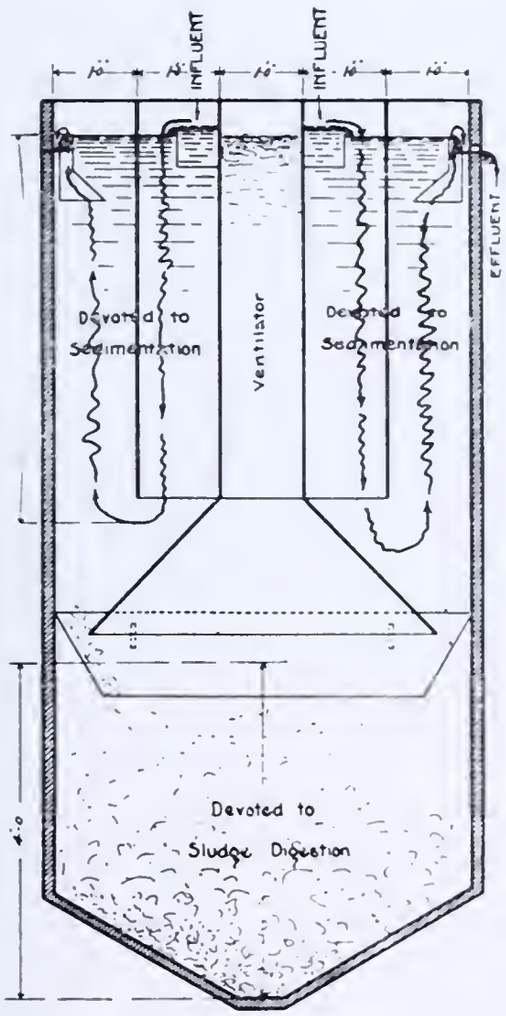


Fig. 5.

In the experimental tank operated at the testing station it was found that the sludge which collected in the lower part of the tank was thoroughly digested, and when withdrawn was inodorous and unobjectionable, best results were obtained by drawing it off in small quantities from the bottom of the tank at least once a week, so that only the oldest and most thoroughly digested sludge was removed. The withdrawal of sludge produces additional agitation in the sludge

chamber and thereby causes fresh masses of sludge to be subjected to bacterial action.

Fig. 6 shows a cross-section of the experimental tank at the Spring Garden testing station. The sludge withdrawn from this tank contained on an average 82 per cent. moisture, but it is believed that from the Emscher tanks which are being constructed at the Pennypack Creek sewage disposal works sludge will be obtained containing as low as 75 per cent. moisture. The importance of obtaining sludge



SECTION THROUGH CENTER OF EMSCHER TANK

Fig. 6.

low in moisture will be evident when it is considered that from the same amount of dry solids sludge 90 per cent. moisture is twice the bulk of that containing 80 per cent. moisture, and sludge 95 per cent. moisture occupies four times the volume of sludge 80 per cent. moisture.

The sludge withdrawn from an Emscher tank contains a large quantity of marsh gas or methane, which gas, when relieved from the

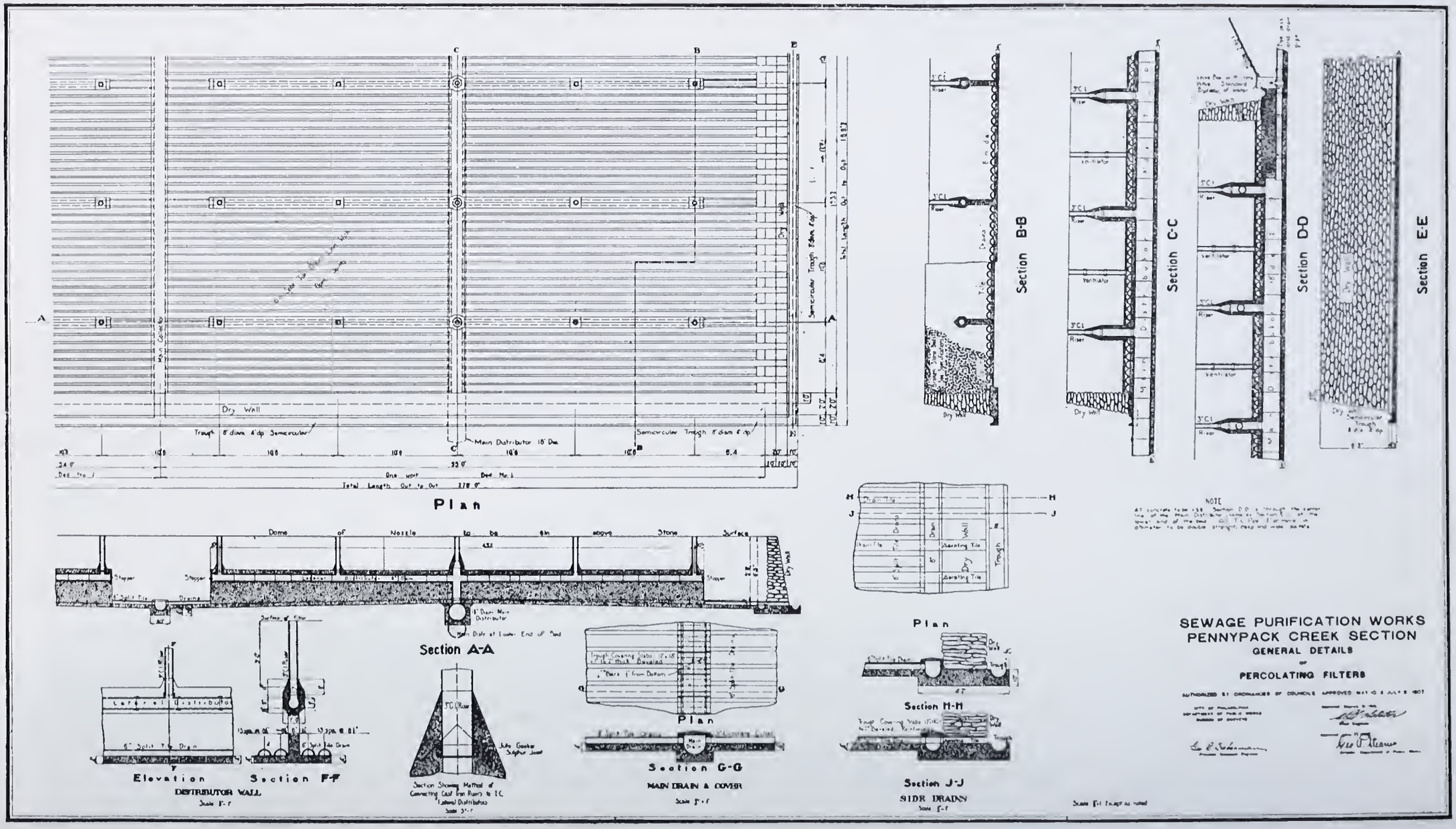

Plan
Section A-A
Section B-B
Section C-C
Section D-D
Section E-E
Section G-G
MAIN DRAIN & COVER
Section H-H
Section J-J
SIDE DRAINS
Elevation
Section F-F
DISTRIBUTOR WALL
SEWAGE PURIFICATION WORKS
PENNYPACK CREEK SECTION
GENERAL DETAILS
PERCOLATING FILTERS

Fig. 7.

hydrostatic pressure in the tank, expands, lightening the mass, allowing it to dry much more rapidly than ordinary sedimentation sludge. It may conveniently be removed from a sludge bed in from five to six days and possesses a tarry odor. When this odor was first observed, it was thought to be due to the fact that some of the sewage at the testing station had come from a gas-works, but from reports from the Emscher district, where tanks of this kind are in use, it appears that this tarry odor is peculiar to digested sludge drawn from such tanks.

At the Pennypack Creek sewage disposal works it is proposed to use for distributing the sewage over the percolating beds a nozzle which will spray in a square, and by this means utilize the largest possible area of the bed. At a number of plants in England the sewage is sprayed over the beds from pipes supported above, but in plants located in the northern portions of this country, owing to the cold winters, it is customary to carry the distributing pipes through the beds with risers to supply the nozzles, thus preventing the sewage from freezing (Fig. 7).

[In reply to questions of several members, Mr. Webster further stated that the capacity of the plant would be two million gallons daily; it is probably capable of treating sewage at even a higher rate. At present about one million gallons will be treated daily, which will allow about four hours' storage in the sedimentation chambers of the Emscher tanks.

The sewage at the point where it enters the pumping station will be intercepted in a chamber where the gravel or coarse sand will be allowed to settle and the floating matter will be intercepted by a coarse screen to prevent injury to the pumps. Provision has been made in the design for placing a fine-mesh screen, if it is found necessary. The amount of suspended solids in the sewage, which is almost entirely domestic from a residential district and from the prison and House of Correction, will be very small, and the Emscher tank will, no doubt, take care of these solids at the present time.

Owing to the fact that the elevation of the present outlet sewers along Pennypack Creek is near low tide, it is necessary to collect the sewage at a low level and discharge it into the pump well at practically minus 18. The elevation of the flow line in the Emscher tank is plus 23, which indicates that it will be necessary for the pumps to raise the sewage a height of 41 feet.

The regulating house is designed to contain the mechanism to

control the flow of sewage on to the filters. All of the experiments that have been made in this city, and those made by engineers at other places, show that an undulating head gives the best distribution on a percolating filter.

The usual method of obtaining this variation of head at the nozzles is by allowing the effluent of the sedimentation tanks to flow into a dosing tank. When the sewage reaches a predetermined elevation in the dosing tank, it is rapidly drawn off by a siphon, and while filling again the filters stand idle. At the Pennypack Creek sewage disposal works, however, the equalizing or constant head tank (shown on Fig. 2) is used and the undulating head is obtained by the opening and closing of a butterfly-valve on the supply-pipe to the filters. This is controlled by a cam actuated by a water-wheel driven with settled sewage. In case of a storm increasing the rate of flow, an electrical device operated by floats in the equalizing tank will automatically throw into service another cam opening the valve wider and so increasing the rate on the filters. In case of accident to the water-wheel the same float in the equalizing tank will, by electrical control, automatically throw into service a motor to operate the cams.]

PAPER NO. 1097.

THE FUNCTIONS OF THE LANDSCAPE ARCHITECT IN CONNECTION WITH THE IMPROVEMENT OF A CITY.

THOMAS W. SEARS.
(Visitor.)

Read January 21, 1911.

MANY members of this Club are, no doubt, vitally interested at present in the betterment of Philadelphia, and it is the purpose of this paper to show in what ways the profession of landscape architecture may be of assistance in planning such betterments, and so the chosen subject is, "The Functions of the Landscape Architect in Connection with the Improvement of a City."

The word "improvement" has been chosen rather than "beautification," which was suggested, because there is no intention to aid an impression which a good many people unfortunately have, viz., that landscape architecture as applied to cities is simply the art of adornment—the art of making very beautiful street lamps, or of having everywhere wonderful flower-beds, and at most of occasionally laying out new streets regardless of whether they lead anywhere or not. It should be distinctly understood at the outset that it is nothing of the sort; that landscape architecture as applied to cities is first and foremost utilitarian; after this, if one can introduce beauty, so much the better. Some one has recently said that cities strive for "beautility," the combination of beauty and utility; but, first of all, it should be remembered that a city must be designed conveniently and economically. Beauty in the highest sense of the word, of course, means a combination of beauty and utility, for unless a thing is useful, it cannot be truly beautiful. If this is thoroughly understood, the title might well be changed to "The Functions of the Landscape Architect in Connection with the *Beautification* of a City."

Under this subject will be enumerated the various ways in which a landscape architect may be of service to a city. However, the subject is such a colossal one that it will be impossible to discuss technically in such a short paper any of the sub-headings, as, for instance, the advantages and disadvantages of the diagonal arrangement of

streets, the gridiron systems, or various other systems or combinations of systems.

The landscape architect may be of service to a city in three distinct ways, as follows:

1. He may be of great service by providing *a comprehensive plan for the development of a city.* A plan which would set aside for commerce, habitation, and recreation those areas for which they seemed best fitted, and a plan which would attempt to solve such tremendously important problems as the transportation, and the related ones of street arrangement and general classification of streets according to use, and the problem of approaches to cities.

2. He may help out very materially by designing many of the elements for public use which he has provided in the plan; such as sites for public buildings and monuments; designs for grounds belonging to schools, institutions, etc.; parks; parkways; park reservations; arboretums and botanical gardens; designs for playgrounds, squares, and plazas.

3. He may promote the general welfare of the city by working out for *individuals*, or *groups of individuals*, designs for real estate developments; private places; groups of private places; private parks; hotel grounds; private school grounds; church grounds; cemeteries; grounds around hospitals; mills; factories; and by having charge of property belonging to railroads and traction companies.

He may also, at times by lectures, personal influence, or some such means, incite people to timely action, but his influence in this field is relatively small, referring now particularly to his position in public work. His position is that of the trained expert who is called in to give advice and embody his ideas in plans; he undoubtedly always will do his utmost to see that his plans are carried out, but that is not essentially *his* work. That is for the people at large, and more particularly for that group of people who are directly in charge of the work; they should have sufficient confidence in the abilities of the man they call in as expert to do all in their power to see that *his* plans are eventually carried out. By this is not meant that a landscape architect should be commissioned to make just one plan for a city, and that this one plan should be adhered to and carried out through thick and thin; for no matter how efficient the landscape architect, conditions are bound to change in unexpected ways at times, and so make changes in the original plan very advisable. The landscape architect should always be with a city, and his advice from

time to time should be taken rather than his first advice. To make his own work easier, the landscape architect's first plan should have that most desirable of qualities flexibility, so that when the unexpected developments occur it will not be necessary to tear down the whole structure of the plan and build up anew.

Some one has recently said that the plans of a landscape architect are like a guide-post, telling the direction and number of miles to a given place; I should like to go this one step further and say that the landscape architect is like a guide—he may try to get people to come on his tour by telling them how interesting it is. Then, if they do not come and miss out on something that is really worth while, it is their fault.

The landscape architect may be of greatest service to the city, as stated above, in providing a comprehensive plan for the city. It is unnecessary to point out the advisability of city planning to enlightened communities; the strange part is that people should not have been awakened to the advantages thus produced years and years ago. One would hardly think of building a house of any size without the aid of an architect; why should not a city, in which the health, wealth, and happiness of millions are concerned, be much more worthy of a design?

Some of the problems the landscape architect has to face to successfully plan a city, briefly stated, are: He must at the outset make a most careful study of the (*a*) physical, (*b*) economic, and (*c*) social conditions existing in the city. It is perhaps needless to point out how vitally these matters are connected with the design; what a controlling factor the topography is, how important a bearing the commercial enterprises may have on the design, or how necessary it is to bear in mind the centers of interest about which the life of the city clusters.

Upon this exhaustive study, so briefly outlined, but which requires much careful application and great skill in passing upon situations and tendencies, depends largely the success of the future plan. From it the designer should be able to determine what localities are best suited to commerce, habitation, and recreation.

The reasons for choosing a locality for a given purpose are both economic and esthetic. For example, it would not be necessary to choose for the site of a big park the most beautiful piece of property; many other considerations should be entertained. Is the site near a community which would need it and use it?

Is it likely to be easily accessible from a greater distance? Is the cost of the property so high that it would be possible to create an equally beautiful park for less money elsewhere? Is it naturally suited for park purposes, or would it mean a great outlay to turn it into a park? Would the return which the location yields as a park be greater than if it were used for any other purpose? The considerations entering into the choice of a locality for other purposes, commerce and habitation, are much the same; many cases could be cited if space permitted.

Fig. 1.—Street in Paris, with through traffic in the middle, local traffic at the side, and planted spaces for promenade.

Certain areas, then, should be conserved for specific purposes; not that this could be done in an absolutely hard and fast way,—as, for example, one could not say that one part of the city should be used entirely for habitation and another for commerce,—but the tendency should be in the direction named, and provision should be made in advance for open spaces for recreation at regular intervals.

The conservation of certain areas for given purposes should be considered along with that tremendously important problem of

transportation and the related problems of street arrangement, classification of streets according to use, and the approaches to cities.

On the subject of *the arrangement and general classification of streets according to use,* it may be said that one of the controlling factors in the arrangement of streets is the transportation problem; that there must be in any well planned city easy and convenient means of communication between one part of the city and another; there must be certain main arteries, which are recognized as such by their width and importance; there must be secondary traffic streets and streets

Fig. 2.—Usual treatment of street in rectangular planned American town.

for a variety of other purposes. Streets should be classified according to their use, and their width should depend on this classification. In some cities standard widths of streets may have been adopted, two or possibly three in number; and standard sizes of blocks. This is a grave mistake. In the first place, one does not with such a scheme get the variety of widths in streets which should be obtained, as some streets will be wider than they should be and others much too narrow; in other words, they are not economically designed to meet their needs. Besides this economic reason against streets of standard width, there is an esthetic one: a city in which the streets

are practically all the same width is monotonous and mechanical, while a city in which the streets vary greatly in width is much more interesting and attractive. The system of standard size of blocks is bad for the same reason, and also because in very thickly settled communities it permits of the dark, unwholesome tenements being erected, a thing which those interested in housing are now fighting so rigorously. Thus it is seen that on the city plan depends in a great measure the question of housing, and to a certain extent

Fig. 3.—Curved street with planting on side to effect seclusion.

the health of the city, for it is in the tenement quarters where the worst diseases breed.

The subjects of streets meeting at rond-points, and of vistas being terminated by some architectural feature, are very interesting. Rond-points in themselves can hardly be criticized, as they often furnish an attractive and suitable location for some architectural feature; if, however, so many streets lead into one rond-point that a congestion of traffic is caused, or if a rond-point is so bulky that it seems a great hardship for through traffic to be made to slow up to

go around it, or if the streets are so numerous that they cause a great interruption to traffic, then the rond-points may well be criticized.

The subject of vistas being terminated by architectural features is closely connected with the latter, and is also well worthy of discussion. It should be borne in mind in this connection that while a vista terminated by an architectural feature is usually very attractive, at the same time vistas beyond a certain number of miles do not count for much, and that on the length of the vista should be determined the size of the feature at the end.

Fig. 4.—Example of seclusion which may be obtained by planting. Houses face Victoria Embankment, London.

There are two main approaches to cities: (1) *On water by boat*, and (2) *on land by railroad*. Along both of these lines of approach land should be taken for public use, and for very different reasons. Take first the use of water fronts: Unless some provision is made for the public, the whole water front, whether it be river or harbor, may be usurped by commercial enterprise and the public deprived of ever seeing the water except when aboard a boat. In certain cases, as in New York, where the water front must of necessity be util-

ized for dockage, a combination of commercial and public use may be successfully employed. There the docks are owned by the city and leased by the steamship companies; in this way their appearance can be controlled. At present it is planned to build on the tops of these docks huge recreation parks which may be used by the public.

The reasons for taking land for public use along railroads are quite different, as there is generally no beautiful view along a railroad track entering a city. The reasons for taking land in such cases

Fig. 5.—Treatment on sides of railroad near Boston.

are as follows: In the first place, the land is always cheap, owing to railroads being essentially noisy, dirty things, from which people try to get away. Railroads invariably make a bad scar wherever they go through a city, and billboards and ugly tenements are naturally enough the things that greet the eye of the visitor. Now, if such land is taken for a park or parkway it may be very acceptable, particularly if the tracks are below the level of the streets rather than above them. This may be readily seen from the illustrations (Figs. 5 and 6).

The complexity of the problem of city planning has perhaps been

indicated by the foregoing remarks. There are two other aims which the successful city planner must always have clearly before him, as he is working out the definite problems touched on above; the first is the need of preserving the city's individuality, and the second is the need of unity in the design. Occasionally some one says how regrettable it must be that a clean sweep cannot be made by doing away with existing topography and conditions. To do this would be like removing the character from a human being; for example, it would be fatal to do away with Beacon Hill, as without it

Fig. 6.—Treatment on sides of railroad, Edinburgh.

Boston would no longer be Boston. Rather the idea should be to retain such features, to make the most of them, and so maintain the individuality of the place. As to the other point, there should be some keynote to the city, possibly a civic center, or even in large cities groups of centers, around which other elements should cluster; subordinate parts should be subordinated, related parts should be interrelated, and so on until in the end there is obtained from all the complex problems involved in city planning a unified result.

I have already enumerated the elements provided for public use

in the plan which the landscape architect might have the privilege of designing. It is only fair to suppose that he who makes this his life work might design these elements better than any one else, and that by his training the landscape architect should be able to conceive of a more beautiful country park, or a more economical and compact design for a city playground in a congested district, than any one else. In this way, then, he might very materially benefit the city.

The third way in which he may promote the general welfare of the city is by working out designs for property belonging to individuals

Fig. 7.—Mt. Vernon Square, Baltimore—a good location for a monument.

or groups of individuals. The trouble here is in getting owners to realize the advisability of employing landscape architects, and yet think what a difference it would make in the appearance of a city if all the private or semi-private property was attractively laid out.

Take, for example, a real estate scheme in a suburban district; the landscape architect, particularly if he was the same man that had made the general plan for the development of the city, would take care that he did nothing to interfere with the best development of the city. Of course, in this way he would also be benefiting the

private property for which he was making landscape designs. And again he would have more regard for the topography than the owner; he would have curved roads rather than straight ones in rolling country, if it seemed advisable on account of the grade and other reasons too numerous to go into; and even if, by so doing, he would be unable to provide the same number of lots in a given territory that could be obtained with the rectangular system. He undoubtedly would make up for this loss by making the lots that he did provide so attractive that the net return would be greater than if the more short-sighted policy were adopted.

Fig. 8.—A well-designed playground in New York city.

There have already been enumerated a long list of private properties which, if laid out by a landscape architect, might work a great change for the better in the appearance of a city. Fitness is the test which should govern the design of all such property. Of all the types mentioned, there is as great an opportunity on mill and factory grounds and land belonging to railroads and traction companies as on any others, if owners could only be made to realize the fact. In the case of the mill and factory grounds where landscape work has been done, not only has the appearance been wonderfully improved

from the point of view of the public, but the work has almost invariably proved a good investment, in that the efficiency of the employees has been increased by their seeming to reflect the surroundings in which they worked. In the case of property belonging to railroads, not only might a great change for the better be worked in the right of way, but also danger from fire might be materially lessened.

An effort has been made in this paper to show clearly that landscape architecture is utilitarian quite as much as esthetic; that whatever one is designing, whether it be a city plan or any of the elements in a city, the design should be governed by use as much as beauty.

Many problems of tremendous interest in connection with city planning have been but briefly touched upon, and some have been left out altogether, owing to the vast proportions of the subject.

However, three distinct ways have been outlined in which the landscape architect may be of service to a city; these are the means; and the end to be arrived at by these means is to make the city, to which more and more people are flocking every day, a better place to live in—a place, more economical, more healthful, and more beautiful. These three things are perhaps in the highest sense the real functions of the landscape architect in connection with the improvement of a city.

DISCUSSION.

Andrew Wright Crawford (Visitor).—Beautification, as beautification merely, is a thing that has absolutely nothing to do, in my judgment, with the planning of a city. When you come to individual small plots of ground, like the confines of a railroad, or parks, you want the best that the landscape architect can give you. But beautification merely for the sake of adding something pretty to the city, is the last thing that any city planner attempts, or ever will attempt, who is worthy the name of city planner.

To tack on beauty to a city is the sort of thing that has been done in this country to a great extent. New York planned a bridge across the East River to cost about twenty million dollars. It had been planned purely from an engineering standpoint. The plan having been adopted, and the movement for the "City Beautiful," so called, having become popular, it was thought politic to tack some beauty on to the bridge. The authorities decided that 2 per cent. or 3 per cent. might be added to the cost, so architects were employed to tack or paste $500,000 worth of beauty to that bridge. But the architects were men who had been doing city planning themselves, and they succeeded in getting the whole thing done all over again and the bridge completely remodeled.

This thing of "prettyfying" a city was a public fad which was adopted perhaps five to fifteen years ago. It seems to me that any beautification should be the result of the general plan of the city, rather than the result of tacking on any beauty to it.

Raymond Unwin, whose book on "Town Planning" has been declared by Frederick Law Olmsted to be the best book yet published on this subject, describes the old form of town planning in this way:

"Civic art is too often understood to consist in filling our streets with marble fountains, dotting our squares with groups of statuary, twining our lamp posts with wriggling acanthus leaves or dolphins' tails, and our buildings with meaningless bunches of fruit and flowers tied up with impossible stone ribbons."

That is what we used to think of as civic art, and this is what nowadays city planning is keeping away from, more and more. The function of beauty in city planning was indicated rather than defined by the elder Olmsted in a paper that was quoted by the younger Olmsted at the city Planning Convention held at Rochester, N. Y., last year, as follows:

"Let a thing be supposed, of greater bulk than the largest of our Fifth Avenue private habitations, to have been made for a mere common purpose of trade by the work of many men,—not one of them ranking among artists, not one of liberal education, men not at all delicate, not nice-fingered, not often even clean-handed; muscular, sweaty, and horny-handed; no small part of them rude and clumsy in their ways, tobacco-chewing, given to liquor, slang, and profane swearing. Suppose the thing so produced to have no beauty of carving or color, to be mainly smeared black and white, and any touch of decoration upon it to be more than barbarously childish and clumsy.

"It can hardly be easy for those who represent what we have been more particularly gaining of late in esthetic culture to believe that such can have given the world a thing of supreme beauty. It will be still harder to realize that the coarse, rude, sensual men producing it had, in general, a deep artistic sense of its characteristic beauty, so that they would protest, in stronger terms than Mr. Ruskin ever used, against the putting upon it of anything by which the rare refinement of it might be marred.

"Alas! that I must speak of this as of a lost art, for it is of the 'Baltimore Clipper' of fifty years ago, the like of which will never again be seen, that I speak. What is this admirableness, dependent on no single thing done for admiration, no decoration, no ornament, no color of splendor, of a sailing-ship?

"Whatever else it may be in the last analysis, it cannot be separated from this fact, that a fine clipper ship, such as we had in America just come to build and rightly sail when the age of such things passed away, was as ideally perfect for its essential purpose as a Phidian statue for the essential purpose of its sculptor. And it so happened, in much greater degree than it can happen in a steamship, or in the grandest architecture, that the ideal means to this purpose were of exceeding grace, not of color, but of form and outline, light and shade, and of the play of light in shadow and of shadow in light. Because of this coincidence it was possible to express the purpose of the ship and the relation and contribution to that purpose of every part and article of her, from cleaving stem to fluttering pennant, with exquisite refinement.

"No writer, poet, or painter can ever have told in what degree it lay in a thousand matters of choice—choice made in view of ideal refinements of detail, in adaptation to particular services, studied as thoughtfully and as feelingly as ever a modification of tints on painter's palette. One needed but a little understanding of the motives of seamanship to feel how in the hull every shaving had been counted, and how in the complicated work aloft every spar and cloth, block and bull's-eye, line and seam, had been shaped and fitted to do the duty required of it in the most sinewy way. These qualities, with the natural stateliness of the ship's motion set off by the tuneful accompaniment of the dancing waves, made the sailing ship in its last form the most admirably beautiful thing in the world,—not a work of nature nor a work of fine art."

Now, it is that beauty of fitness that the city planner should endeavor to carry out; he should plan on broad lines, and he should carry out on broad lines.

Mr. Sears has suggested some of the many things that go into the making of city planning. At the first session of the City Planning Conference in Washington, which lasted for two days, certain things were discussed; at the second conference, in Rochester, others were discussed. The third convention is to meet in Philadelphia in May, by invitation of the Mayor, and in the three days at our disposal, we are to consider a few of the subjects of city planning touched upon by Mr. Sears.

I do not propose to ask you to listen to me while I endeavor to describe the many things that go into city planning, but the problem of those scars that run across our cities, namely, our transportation lines, is one thing to consider. The first thing to determine is, how are you going to transport the public to and from its work at all hours of the day? That covers transportation by streets, and not only by railroads or traction lines. The solution of the transportation problem is the fundamental element in city planning. Upon that is dependent the width of the city streets and their location, the sites for various public buildings, and the homes for the people, as well, because, closely bound up with the question of the kind of home a man has, is the question of how far he lives from his work. A man cannot live more than an hour from his work at most. Most men cannot live that far. If, then, the means of transportation are inadequate, men have to live huddled together within short distances of their work. Thus, increase of rent and the evils of congestion result. I do not propose to go into what "congestion" means. Mr. Benjamin C. Marsh, who has done a great deal in the matter of relieving the congestion in New York city, asked us to consider at Rochester the enormous problem of 1500 people living on one acre of ground. Mr. Veiller, who is disputing, perhaps successfully, with Mr. Robert W. de Forest leadership in solving the housing problem, denied that 1500 people per acre necessarily meant congestion, and cited as an example the Plaza Hotel, where 2000 to 2500 people live on an acre, which does not exactly represent any very bad "congestion." Therefore the number of people living on one acre does not necessarily mean bad housing conditions. It does mean, however, a more difficult problem of transportation.

The problem of transportation necessarily correlates itself with that of housing. It also vitally affects the planning of the park system, a subordinate element of city planning. The street system and the park system should be considered together, or bad results will follow. Central Park in New York is situated so as to cut off exactly one-fifth of the chief means of transportation north and south. It shuts off Sixth and Seventh Avenues most effectively, and consequently enormous crowding must take place both east and west of Central Park. The men who plan so as to cut off means of transportation do a vitally wrong thing. The details which go into city planning—circles, fountains, embellished lamp-posts, etc.—are all subsidiary to transportation.

Our worst housing conditions in Philadelphia were the best fifty or seventy-five years ago. The houses were built for the well-to-do. The rich people moved away, and the poor people came in. They could not rent the whole house, so it was divided up into tenements, and the handsome library at the back of the house became a part of the back-tenement fronting on an alley formerly a part of a side-

yard. I think you will find that north of Market Street and east of Broad is to be a region of two-story houses. This we cannot say absolutely, but we must plan so as to be able to meet the conditions as they change. The city plan must be elastic. Not so many years ago we said that at Fourth and Chestnut Streets was the business center; we now consider the City Hall as the center of the city. Walnut Street is being given up to business. You must plan your residential area so that it will not be a misfit when it becomes a business area.

Here in Philadelphia our housing conditions for the working people are the best that have been put into practice on a big scale. These conditions can last so long as, and no longer than, the means of transportation by the streets and by the transit and railroad systems are adequate to enable the workman to get to his work and back again, at quick speed, at short intervals, and at cheap rates. I want to impress upon you, finally, that beautification, as beautification, is the last thing to be considered in city planning, and not the first thing. A city should be planned to meet its needs, and when you have done that, the beauty that will result from right means to right ends will be like the beauty of a sailing ship—the beauty of fitness.

Leslie W. Miller (Visitor).—I cannot say very much, indeed I did not know that I could say anything at all until Mr. Crawford said something about the relative importance of the city beautiful idea, and I would like to talk back at him a little.

The importance of this subject cannot be overestimated. We are just beginning to realize it here in Philadelphia, and I think it is the duty of every such body as this to do its part to promote discussion. Wherever men gather with any such purpose as this Club gathers with, I think it is a large part of their duty to make it their business to think and help others think and feel rightly on such problems as this, and when things are proposed with the definiteness that they are from time to time, I think it is the business of all of us to make the result of such co-operation and reflection as this Club represents felt in the community. We have fool propositions—like that building of a convention hall on the Schuylkill, for instance—coming up, and I think it is your business to turn out and help quash it. I looked in the newspapers morning after morning for some effective protest against that sort of thing, from engineers, architects, artists, and public-spirited men of Philadelphia. I think one protest appeared over the signature of a member of this Club, and I think that is the one honorable exception to the silence that is easily mistaken for apathy if not for indifference. There is so much said on the wrong side of this question that it is a pity that nobody raises his voice the other way. I think every such organization as this ought to devote a lot of attention to things like these. The lawyer, the doctor, the architect, the artist, all professional men, are, in their individual capacities, occupied with private practice; but what they do in their clubs and societies is to discuss the things that concern the public welfare. In this way they can do a lot of good in promoting public measures on lines that their combined professional judgment approves, and I hope the Engineers' Club will do its part.

The difficulty with this city planning is that it is all so new. We have allowed our cities to just grow without giving a thought as to *how* they should grow. Now, the law of life is the law of growth, and the law of growth is the law of change.

The problems that we have to face today,—this very question of transportation, for example, that has assumed so much importance in this discussion already,—will never stay solved, however satisfactory any temporary solution may be. We can see certain things to be done here to improve conditions—probably in ten years from now the problem will be entirely different. The Pennsylvania Railroad will probably not enter the city in the way it enters it now at all, and an entirely new problem will have arisen in that connection. We have no idea of the size of the city of the very near future, and continually speak of places a few squares away from City Hall as "remote."

Everything that we do, then, must be regarded as temporary, and the city planner will be always with us if the city is alert and alive, and the professional man ought to make it a prominent part of his duty to render the best service he can by giving in the most unselfish way such advice and direction as he can to the community of which he is a part, which direction will probably, as a rule, be most effective if it comes from just such organizations as this Club.

Now, just one word as to the guiding principle that should underlie a good work of this kind. I am afraid my good friend Mr. Crawford is a little off in what he has had to say about the esthetics of city planning; he is only a lawyer; he is not used to speaking in public; he got a little rattled, and he did not make his definitions particularly clear. I want to explain for him. He said some things in the way that lawyers are accustomed to say them,—they get so accustomed to trying to make "the worse appear the better reason"—he said, or he made you understand that he meant to say, that "the pursuit of beauty was a false guide in the planning of cities." He did not really mean to say that. The things he condemned, he condemned as ugly—did you notice that? He referred to this *ugly* gash that crosses our city; and it was because it looked like the mischief that he condemned it, not because it was uneconomical. So his heart was all right, even when his explanations were all wrong.

Now, the determination to make a thing beautiful, if we can, is the safest guide with the city plan or almost any other kind of plan. Many things have to be reckoned with and compromised on, and the *necessary* result has to be accepted everywhere; but the aim should be to make the thing beautiful if we can.

You plan, you cultivate, you strive for, and dream of, beauty, for beauty is nothing but the bloom on the cheek of health. You want health, of course; you want your city to be healthy and you have a right to hope and think it will then be beautiful; but the best and simplest guide you have to work by, the thing that you can comprehend most readily and will be least likely to be misguided by is your desire to have things look right. When the greatest of all mayors said to the inhabitants of Athens, when her title to the leadership of Greece was recognized by the other cities, and when all the states of Greece brought to her their share of the funds for the common defence, Pericles said to the other folks in the city, "You cannot do better with that money than make Athens the most beautiful spot on the face of the earth." He was quite right. He might have laid out many plans that were utilitarian, and run out a lot of lines for her material development which might or might not have been followed up, but his proposition was something definite, that everybody, from the child to the oldest gray head, could understand and that he could hope to see accomplished in his own lifetime.

When Mr. Sears showed the views of the country just now, and showed you how it should be developed as population increased, and besought us to allow the streets to follow the inclines in such a way as to respect the natural forms of the hills, he meant that we ought to respect the beauty of the landscape. And so when we plan the placing of houses for any community, we ought to stop and think, How is the scheme going to look when it is finished? I submit respectfully that this is the best possible guide you can have in planning cities, or houses, bridges, entrances, gateways, stairways or what-not, and that when we leave that path and become ashamed of that guide, we are going wrong.

A few years ago another horrible monstrosity was being worked out across the Schuylkill, and I think I was the only one who raised a single word of protest. I sent a letter to the "Public Ledger," and I think it was the only one. It was that abomination that comes up out of the ground on this side of the river and wiggles like a wounded snake going up-hill over into West Philadelphia. I was answered almost immediately by the editor of one of the great dailies. He said that to raise the question of looks was all wrong; that this was a utilitarian age, and we had to accept the utilitarian things—eyesores or not, they have got to be accepted. Now, I say they are not bound to be accepted. Wherever proper associations exist for the protection of the public, this principle of the importance of good looks will assert itself, as it does in New York today. In New York such a thing as that would not go through, and the bridge would have had to be designed on better lines. You will never have such oversight here, however, until you have a commission to regulate these things. Such a commission is our only hope in Philadelphia. It will not be an engineers' commission, as such; it will not be an economists' commission, as such; it will not be a housing commission, as such. It will be an art commission, as it is in New York. It is not, in the main, a question of anything else but how the city ought to look. When it was proposed to build the Hudson bridge, the designs were submitted not to the economists, and not to the engineers, but to an art commission, who represented the feeling and the sentiment of the whole community, and it said, "No; you cannot put up such a looking thing as that." A very simple problem and the whole scheme had to be revised along lines that had some approach to beauty, and when the Pennsylvania Railroad Company planned its bridge across Hell Gate, it did not publish its design until the same had been submitted to that same art commission, and I respectfully submit that that regard for the way the thing is going to look is the best and safest guide we can have for city planning everywhere.

I want to say one word more, and ask the gentlemen that they are not to confuse beauty with ornamentation. There is some danger of doing that. I am making no plea for ornamentation; no one despises a plastered-on clot of ornaments as much as I do. It is my business to despise it, and to teach others to despise it, as principal of an art school, to teach pupils what is art and what is not art; it is my duty to teach them to despise ornamentation as such. It was Owen Jones who said: "Ornament should be constructed. Construction should not be ornamented." Let us give a thing its right lines in its development. If a building follows the lines of its growth, as the tree does, the beauty of it will be a natural result. Beauty is the expression of right development, so please do not confound ideas of beauty—as they are taught, as far as I know, in every

art school in the world—with ideas of ornamentation, either right or wrong, which, however, is another story.

B. A. Haldeman.—I think Mr. Sears' paper and the resulting discussion have been very timely and interesting, as bringing the members of the Club into closer intimacy with that phase of the great problem of city planning which aims toward a larger consideration of esthetic and attractive elements in the work of municipal improvement.

It has been suggested that I should furnish some information in reference to the comprehensive plan for the improvement of Philadelphia, but I do not feel that I can discuss that subject at the present time except in a general way. Although city planning, in its broadest intent, has been receiving marked attention throughout the country for a number of years, I do not think our people have become accustomed to regard the work involved in it as anything of very large importance or of very great necessity; its importance is, however, clearly recognized by those who are engaged in trying to solve the social and industrial problems of our large and rapidly growing cities. It is not a fad or a fancy, but a strong and earnest forward movement, in which every city must take an active part if it hopes to keep in step with modern civic progress.

The "city plan" is generally understood to mean only a plan of streets, but to be "comprehensive" it must go much further and include every civic improvement which contributes to the progress and welfare of the community, and over which the people, or their authorized representatives, may exercise control. It involves a broad view and wise forethought in working out all the large problems which go toward the building up of a great city; it is not sufficient that present needs be satisfied, but opportunities for healthy development along progressive and economical lines during a long future of usefulness must be provided.

It is not the planning of additions or extensions to the city that causes us the greatest concern, for although that offers some serious problems, we should be able to cope with them with a large degree of success if we are sufficiently broad-minded and progressive to profit by the knowledge and experience of recent years in both American and European town planning.

It is only natural that a city should continue to grow along the lines of the plan upon which it was started, and that is what has happened in Philadelphia. The plan of 1683 has been extended through more than two centuries, until a time has been reached when radical changes and improvements must be made if the intensive industrial and commercial enterprises essential to the prosperity of the modern city are to be fostered and encouraged. We are all familiar with the unfortunate conditions which exist in the central part of the city, and the relief of those conditions and the prevention of their aggravation and extension to other sections is one of the most important problems of our comprehensive city planning. A permanent solution of this problem will involve drastic measures and large cost, but such measures have been resorted to in other cities and have resulted in large material benefits.

Transportation has been referred to as being the most important problem to be considered in city planning. Transportation, or, to use a broader term, circulation, is unquestionably the basis of municipal progress, and normal and unobstructed circulation depends primarily upon the street system. Wherever an active, thriving, progressive community is found, good transportation facilities

will be found, and wherever such facilities are lacking or neglected, civic retrogression and decay will be apparent.

The facilities for transportation and general circulation in Philadelphia can only be permanently improved in those sections where improvements are most necessary by the opening of new streets and the widening of existing ones. Such work is not new or novel; many of the large cities of the world have this same problem to deal with and have solved it, or are solving it, in this manner, and find that it pays.

About sixty towns and cities in America have prepared plans of a more or less comprehensive character which provide for their future growth in a definite and systematic manner; those of Washington and Chicago are the most ambitious and inspiring; all of them find it necessary to do considerable replanning and rebuilding, and in several of them this work is now in progress.

The comprehensive plan also contemplates the general improvement of the harbor, docks, and waterways for commercial purposes, and the construction of embankments with a view of obtaining attractive architectural and landscape features overlooking the streams where the banks may not be required for shipping purposes.

A general scheme of park, parkway, and playground extension has been worked out reaching and serving every section of the city, and these features will be linked together in such a way that we hope the completed system will furnish ample opportunity for the outdoor recreation and pleasure of many generations of the people. The park area actually owned by the city or upon the city plan has been increased more than 50 per cent. during the past five years.

The creation of opportunities for ornate and attractive development, and the encouragement of higher ideals of civic art, must go hand in hand with the consideration of the necessary and useful features of the city plan, and we are endeavoring to give all of these considerations proper weight in the work we are now doing. An illustration of past failure in matters of civic design is found in the statues and memorials which surround the City Hall, the location and arrangement of which have been publicly criticized by competent authorities, but there is no suitable place available for them at the present time. Monuments and memorials are distinctive features in the embellishment of all cities, but unless proper sites are provided for them, much of their character, dignity, and effectiveness as memorials of men and events or as works of art is entirely lost.

All our large cities are forging steadily ahead in the planning and in the execution of the work necessary for the development of the great city of the future, and in preparing a comprehensive plan for improvement Philadelphia proposes to maintain her distinguished position and be an active participant in the progress and prosperity of the coming years.

John C. Trautwine, Jr.—The discussion between Messrs. Crawford and Miller (advocating, respectively, "utility" and "beauty") has interested me particularly, and has reminded me of the statement (which, I believe, is an article in the creed of the transcendental mathematicians) that there is but one infinitely distant point in the universe, and that all directions lead to that point.

Mr. Crawford tells us that, in city planning, we should strive only for utility; Mr. Miller tells us we should strive only for beauty. If Ruskin is right in main-

taining that everything is beautiful which properly fulfils its functions, then surely both gentlemen are right; for then utility *is* beauty—and vice versa; and it matters not for which we strive. If we strive for utility—and attain it—then we get beauty too, for it is the same thing. If we strive for beauty—and get it—we must get utility too, for we cannot have one without the other.

The occasion for the dispute lies in the difference between our notions as to what constitutes beauty. Happily we are outgrowing the notion that white-and-gilt figureheads on ships and flummery on locomotives are beautiful; but the false notion, in favor of mere ornament, persists in such examples as the sheet-iron arches which once disfigured the truss panels of our Spring Garden Street bridge and the absurd (because meaningless and useless) massive stone towers which still stand at the ends of the truss, in the monstrosity which the "beauty" people have insisted upon for the Long Island Pennsylvania Railroad bridge, and in the senseless and disfiguring stone tower with which, at an expense of some half-million dollars, they have "beautified" the fine stone Cambridge bridge across the Charles River at Boston.

The rapidity with which the zeal for city planning is coming to the fore is profoundly significant of the vast social change by which the individual is being subordinated to "the common-sense of most," to the infinite advantage of the individual himself. Just as the individual gained the invaluable freedom to go about unmolested, by surrendering the useless freedom to knife or shoot his fellow-man, so he is being transformed from a pauper to a multi-millionaire by being deprived of the privilege of beggaring himself and the country by senseless competition, and is being made the recipient of incalculable benefits which flow to him through the concerted action of the community.

ANNUAL REPORT OF THE BOARD OF DIRECTORS

For the Fiscal Year 1910.

January 28, 1911.

To the Members of The Engineers' Club of Philadelphia:

The Board of Directors herewith presents its report for the year ending December 31, 1910, as follows:

Eighteen stated and one special meetings of the Club were held, at which the maximum attendance was 156 and the average 105. Nine regular, two special, and four adjourned meetings of the Board of Directors were held.

The summary of membership on December 31, 1910, as compared with the summary of December 31, 1909, is as follows:

Class	1909			1910		
	Resident	Non-Resident	Total	Resident	Non-Resident	Total
Honorary	2	2	4	2	2	4
Active	411	97	508	367	97	464
Associate	51	2	53	56	5	61
Junior	50	9	59	49	10	59
	514	110	624	474	114	588

Twenty-eight Active, eighteen Associate, eighteen Junior and one Honorary Member were elected; one Associate Member was transferred to the Active grade; nine Juniors to the Active grade, and one Junior to the Associate grade; one Honorary and seven Active Members died; sixty-five Active, eight Associate and five Junior Members resigned; fourteen Active, three Associate and four Junior Members were dropped from the rolls, and four Active, one Associate and one Junior member were reinstated to membership.

Although the membership given for December 31, 1909, is 624, a number of resignations tendered on account of the increase in dues were not acted upon until January 15, on which date the membership dropped to 588. Taking that as the proper beginning of the new year, it will be noted that the total membership has remained exactly stationary.

The record of deaths is:

Thomas C. Craig, Active Member, died January 26, 1910.
John H. Converse, Active Member, died May 3, 1910.
Eugene D. Hays, Active Member, died June 3, 1910.
George W. Hayes, Active Member, died June 20, 1910.
Wm. D. Beatty, Active Member, died June 23, 1910.
Silas G. Comfort, Active Member, died July 12, 1910.
Washington Jones, Honorary Member, died July 15, 1910.
J. W. Ruddach, Active Member, died November 6, 1910.

The following papers have been presented before the Club:

January 4—"The Destructive Effect of Motor Traffic on Road Surfaces, and Methods of Construction to Prevent It." W. H. Fulweiler (Active Member).

January 15—"The Disinfection of Water and Sewage." Earle B. Phelps (Visitor).

February 5—Annual Address—"Recent Developments in Engineering Practice." President W. P. Dallett.

February 19—"Some Notes on Wood Preservation and Creosote Production Abroad." Ernest A. Sterling (Active Member).

March 5—"A Labor-Saving Corporation and a Profit-Sharing Corporation." John C. Parker (Active Member).

March 19—"The Principles Involved in the Design, Construction and Operation of Submarine Vessels." Simon Lake (Visitor).

April 2—"The Economic Value of Motion Study in the Trades." Frank B. Gilbreth (Visitor).

April 16—"The Development of Correct Notions as to the Form and Position of the Earth." Henry Leffmann (Active Member).

April 30—"A Trip Across Panama; Life and Conditions on the Canal Zone." Martin Nixon-Miller (Active Member).

May 7—"The Fruhling Suction Dredge." John Reid (Visitor).

May 21—"An Automatic Signal for Electric Railways." Carl P. Nachod (Active Member).

June 4—"The Construction of a Rapid Transit Railroad in Relation to the Handling of Passengers." J. Vipond Davies (Visitor).

September 17—"The Design and Operation of a Modern Classification Yard." W. A. MacCart (Visitor).

October 1—"Smoke Abatement." D. T. Randall (Visitor).

October 15—"Military Engineering." Curtis W. Otwell (Visitor).

November 5—"The Building of a City." Henry Leffmann (Active Member).

November 19—"The Chief Engineer as Interpreter and Arbitrator." Alexander Simpson, Jr. (Visitor).

December 3—"The Erie Railroad Four-Track Cut and Tunnel Line Through Bergen Hill, Jersey City." A. L. Moorshead (Visitor).

December 17—"Some Late European Experiences in Water and Sewage Works and Refuse Destruction." Rudolph Hering (Active Member).

The Junior Section held four meetings, the last being in April. Following this last meeting, the Juniors met and decided to postpone further meetings of the Section indefinitely, most of them being unable to attend both the meetings of the Section and the regular meetings of the Club, and preferring to confine their efforts to attendance at the regular Club meetings. No attempt has been made during the present winter to reorganize the Junior Section.

A reception and dance on April 25 and a smoker on November 7 each had an attendance of about two hundred and fifty members and guests. The expense of both functions was met by subscriptions from members of the Club, and both accounts showed a credit balance which has been used to defray the expenses of Club nights, held each Monday evening.

The Board of Directors, at its meeting on May 19, recognizing the necessity of making certain alterations and improvements to the Club House, passed a resolution, authorizing the negotiation of a loan of eighty-five hundred dollars

to be raised for this purpose, the amount of the loan being subsequently raised, by resolution, to ninety-five hundred dollars. These improvements included the following:

The fourth floor of the rear building, formerly occupied as office and library, was divided with partitions, creating six additional bedrooms and one bathroom. The library was moved to the second-story, occupying the former billiard room. The billiard tables were moved to the front basement, occupying part of a room used also as a rathskeller and cardroom. The general office was concentrated on the first floor. The enclosing walls of the rear parlor were removed, throwing that entire space into a large lobby, and, finally, a modern steam-heating plant was installed, replacing two old-fashioned hot-air furnaces.

In addition to the alterations and improvements in the building, the expenditures of the Building Committee included the purchase of furniture for the new rooms, rugs in the lobby, the repainting of the entire house, and several other miscellaneous improvements.

The financial report of the Building Committee having charge of this work is appended herewith. The returns from these improvements for the last three months have exceeded an annual rate of 10 per cent. on the investment, and the desirability of these improvements has been shown by the fact that the patronage of the house has increased by over 50 per cent. compared with a corresponding period last year.

BUILDING ACCOUNT.

Summary of Expenditures.

Pay-roll of laborers	$1,945.41
Bills paid up to December 1, 1910	3,846.84
Bills certified up to December 28, 1910	1,066.86
Bills due	1,540.89
Notes issued	1,100.00
	$9,500.00

Summary of Receipts.

Cash Received:	
Loans from members secured by notes at 5 per cent	$7,600.00
Sale of junk	32.53
Interest on deposits	6.70
	$7,639.23
Expenditures on vouchers drawn to December 26	6,627.23
Cash in bank	$1,012.00
Amount necessary to meet entire obligations	$1,860.77
Amount necessary to meet bills due	$768.70

Owing to the confusion incident to the building improvements, the library has not been given the attention that is desirable, and the only expense incurred has been for the binding of periodicals. It is hoped, however, that funds will be available during the coming year for its improvement.

The Publication Committee reports difficulty in preparing for publication the informal remarks made by members in the meetings, and suggests that it would be desirable for members to present written discussions to the papers whenever

possible. As the standing of the Club outside of Philadelphia is judged largely by the character of its publication, the committee is anxious to improve it as much as possible, and will gladly entertain suggestions from members to this end.

Financial Report.

The following is the report of the accountants and auditors who have had charge of the books of the Club:

STATEMENT OF ASSETS AND LIABILITIES
As at December 31, 1910.

ASSETS.

Cash—Colonial Trust Co.—Active Account	$623.62	
Colonial Trust Co.—Interest Account	1,534.11	
In Office	171.07	$2,328.80
Accounts Receivable, Members' Ledger		3,181.23
Inventory of Supplies on Hand.		
Wines and Liquors	$251.23	
Cigars	65.00	
Fuel	66.00	
Restaurant—Provisions	89.14	471.37
Property.		
Building No. 1317 Spruce street	$72,850.59	
Furniture and Fixtures—House	8,791.40	
Furniture and Fixtures—Restaurant	1,229.59	
Library	2,159.57	$85,031.15
Insurance.		
Perpetual on Club House	$1,782.00	
Unexpired on Furniture	43.56	1,825.56
Miscellaneous.		
Bonds Deposited by Link Belt Engineering Co.		$1,000.00
Sinking Fund for Bond Redemption		403.39
Total Assets		$94,241.50

Liabilities.

Accounts Payable		$2,635.26
Bills Payable		2,500.00
Bills Payable—Building Account		9,500.00
First Mortgage	$40,000.00	
Second Mortgage Bonds	26,750.00	66,750.00
Accrued Interest—First Mortgage	1,080.00	
Accrued Interest—Second Mortgage Bonds	1,527.50	2,607.50
Carried forward		$83,992.76

Brought forward		$83,992.76
Initiation Fees due Bond Reserve		730.00
Reserve for Bond Redemption		403.39
Link Belt Engineering Co.—Fund		820.00
Reserve for Redemption of Link Belt Bonds		180.00
J. A. Vogleson, Treasurer		93.22
Christmas Fund.		
Balance January 1, 1910	$44.50	
Contributions December, 1910	238.50	
	$283.00	
Disbursements December, 1910	250.00	33.00
Total Liabilities		$86,252.37
Surplus.		
Surplus as at January 1, 1910	$3,315.57	
Less Accounts charged off applying to prior periods	83.45	
	$3,232.12	
Refund of Interest on Link Belt Bond	100.00	
Reserve for Bond Redemption Transferred upon cancellation of Bonds out of Sinking Fund	3,250.00	
Gain for Year 1910 as per Statement of Income and Expense	1,407.01	
Surplus as at December 31, 1910		7,989.13
		$94,241.50

STATEMENT OF INCOME AND EXPENSE

Year Ending December 31, 1910.

INCOME.

Dues—Net		$17,079.70
Publications.		
Advertising—Directory	$585.00	
Advertising Proceedings	775.55	
Sales Proceedings	169.25	
Sales Directory	3.00	
Total from Publications		1,532.80
Miscellaneous.		
Interest on Deposits	33.22	
Rent of Meeting Room	96.00	
Reception Committee	238.00	
Credit for Interest on Perpetual Insurance	89.16	
Badge Sales	32.00	
Smoker Contribution	22.95	
Transfer from Girard National Bank Account	85.04	
Reprints	17.40	
Total Miscellaneous Income		613.77
Carried forward		$19,226.27

Brought forward		$19,226.27	
Club-house Business.			
Restaurant Sales	$8,011.97		
Wine Sales	1,024.85		
Cigar Sales	1,268.45		
Billiards and Pool	210.12		
Lodging	2,607.41		
Total Income from Club House Business		13,122.80	
Total Income Year ending December 31, 1910			$32,349.07

EXPENSES.

Salaries and Wages.			
House Salaries and Wages	$2,746.36		
Secretary's Office Salaries and Wages	1,127.30		
Treasurer's Office Salaries and Wages	1,889.85		
Restaurant, Salaries and Wages	3,819.14		
Total Salaries and Wages		$9,582.65	
Expenses.			
House Expense	$1,492.77		
Secretary's Office Expense	183.56		
Treasurer's Office Expense	233.47		
Total Expense		1,909.80	
Publications.			
Directory Publishing	$294.40		
Proceedings Publishing	1,295.44		
Reprints	57.85		
Total Publications		1,647.69	
Miscellaneous.			
Gas and Electric Light	$921.92		
Telephones	126.18		
By-Laws Revision	27.70		
Club Luncheons	396.00		
Meetings	483.04		
Membership Committee	143.87		
Reception Committee	225.22		
Smoker	26.65		
Taxes and Water Rent	927.90		
State Tax on Bonds	126.00		
Insurance	140.16		
Badges	33.00		
Expenses Trustees' Bond Redemption Fund	4.50		
Total Miscellaneous Expense		3,582.14	
Interest and Discount.			
Interest on First Mortgage	$2,160.00		
Interest on Second Mortgage Bonds	1,287.50		
Discount on Notes	75.83		
Total Interest and Discount		3,523.33	
Carried forward		$20,245.61	

Brought forward		$20,245.61	

Club-house Business.

Restaurant Purchases	$7,505.80		
Restaurant Supplies	166.22		
Restaurant Ice	202.16		
Restaurant Laundry	219.98		
Restaurant Fuel	271.53		
Restaurant Equipment	54.39		
Restaurant Renewals and Breakages	242.88	$8,662.96	
Wine Purchases		749.31	
Cigar Purchases		990.22	
		$10,402.49	

Inventory December 31, 1910.

Wines and Liquors	251.23		
Cigars	65.00		
Fuel	66.00		
Restaurant Provisions	89.14		
	$471.37		

Inventory January 1, 1910.

Wines and Liquors	$188.89			
Cigars	64.84			
Coal and Wood—House	25.00			
Restaurant—Provisions	87.50			
Restaurant Coal	3.25	$369.48		
Deduct Increase in Inventory			$101.89	
Total Club House Business, exclusive of Salaries and Wages			$10,300.60	

Depreciation.

Furniture and Fixtures—House	$331.13			
Furniture and Fixtures Restaurant	64.72	395.85		
Total Expense Year ending December 31, 1910				$30,942.06
Net Gain Year ending December 31, 1910				1,407.01
				$32,349.07

Respectfully submitted,

J. A. Vogleson,
Treasurer.

The above report has been prepared by the accountants employed by the Club. The auditors have examined accounts taken at random and believe that the report as set forth above is correct. The bank balances are correct.

W. B. Riegner,
Wm. C. Kerr,
D. Robert Yarnall,
Auditors.

The following is the report of the Trustees of the Bond Redemption Fund:

January 7, 1911.

Third Annual Report of the Trustees of the Bond Redemption Fund, being a statement of business for the year 1910:

Receipts.

1910.				
January	1.	Balance on hand	$560.14	
January	29.	Coupons collected	5.00	
February	8.	Initiation fees	275.00	
March	18.	Initiation fees	155.00	
July	1.	Interest on deposit	2.32	
December	2.	Initiation fees	290.00	
December	31.	Interest on deposit	1.48	
				$1,288.94

Expenditures.

January	29.	Bond bought	$45.00	
January	31.	Bonds bought	241.05	
February	8.	Bond bought	495.00	
March	23.	Interest on Link Belt bonds refunded	100.00	
June	15.	Box rent	3.00	
November	22.	Notary's fee and postage	1.50	
				885.55
		Balance January 1, 1911		$403.39

The duties of the Trustees under paragraph first of item C, rule 2, of the provisions adopted by the Board of Directors March 21st, 1908, for the redemption of secured mortgage bonds, having been fulfilled, the Trustees proceeded to carry out the provisions of paragraph second, as amended by the Board of Directors January 4th, 1910, and advertised for offers for sale of second mortgage bonds. From offers received the Trustees purchased bonds to the par value of $800.00 and accrued interest for the gross sum of $781.05. By subsequent order of the Board of Directors these bonds, together with the bonds of the Link Belt Company, were cancelled, and all bonds, with cancelled unmatured coupons, were delivered to the Trust Officer of the Colonial Trust Company, trustee under the second mortgage. The Trustees, therefore, now hold no negotiable securities of the Club.

Respectfully submitted,

HENRY LEFFMANN,
EDWIN F. SMITH,
EDGAR MARBURG,
Trustees.

The Auditors have examined the Trustees' account and found it to be correct.

W. B. RIEGNER,
WM. C. KERR,
D. ROBERT YARNALL,
Auditors.

Respectfully submitted,

THE BOARD OF DIRECTORS,

WM. EASBY, JR.,
President.

W. P. TAYLOR,
Secretary.

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, January 7, 1911.—The meeting was called to order by President Easby at 8.35 p. m., with 124 members and visitors in attendance. The minutes of the regular meeting held Saturday, December 17th, were approved as printed in abstract.

The President announced that at an adjourned meeting of the Board of Directors held December 29, 1910, Dr. Edgar F. Smith, had been elected to Honorary Membership in the Club.

Following a report of the Tellers, the President declared the following elected to membership: Active, Walter Francis Drueding and William Mitchell Irish; Junior, Charles W. Bell, Boyle Irwin, Jr., Richard Coxe McCall, Arthur C. Merrill and George Justice Mitchell.

Mr. Thomas H. Wiggin, Visitor, presented the paper of the evening, entitled, "New York City's Additional Water Supply from the Catskill Mountains," which was discussed by Messrs. H. M. Chance, C. P. Birkinbine, L. F. Rondinella, S. M. Swaab, Wm. Easby, Jr., and others.

On motion of Mr. Swaab, the thanks of the Club were extended to Mr. Wiggin for his interesting and instructive paper.

Special Meeting, January 13, 1911.—The meeting was called to order by President Easby at 8.30 p. m., with 118 members and visitors in attendance.

Mr. F. H. Newell, Director of the United States Reclamation Service, presented the paper of the evening, entitled, "Engineering Work of the Reclamation Service," which was illustrated by a number of exceptionally interesting lantern slides. Upon motion, the thanks of the Club were extended to Mr. Newell.

Regular Meeting, January 21, 1911.—The meeting was called to order by President Easby at 8.35 p. m., with 102 members and visitors in attendance. The minutes of the Business Meeting held Saturday, January 7th, were approved as printed in abstract.

Mr. Thomas W. Sears, visitor, presented the paper of the evening, entitled, "The Functions of the Landscape Architect in Connection with the Improvement of a City," which was discussed by Messrs. Andrew Wright Crawford, Leslie W. Miller, John C. Trautwine, Jr., Edward S. Hutchinson, John C. Parker, James Christie, B. A. Haldeman and others.

On motion of Mr. Swaab, the thanks of the Club were extended to Mr. Sears and to the visitors who contributed to the discussion.

Special Meeting, January 30, 1911.—The meeting was called to order by President Easby at 8.30 p. m., with about 30 members and visitors in attendance.

Prof. A. M. Christen presented the paper of the evening, entitled, "Esperanto: Its Benefit to the Engineer," and was followed by a general discussion in which a number of those present participated.

Thirty-second Annual Meeting, February 4, 1911.—The meeting was called to order by President Easby at 8.35 p. m., with 102 members and visitors in attendance. The minutes of the Special Meeting, held Friday, January 13th, and the Regular Meeting, held Saturday, January 21st, were approved as printed in abstract. The Annual Report of the Board of Directors was presented and approved. Following a report of the Tellers, the President declared the following elected to membership: Active, Frederick M. Shepard; Associate, Charles P. Perkins, William H. Scott, Martin Stotz, Walter J. Warner; Junior, Jamard R. Zeckwer.

President Easby, after relinquishing the chair to Vice-President Hess, delivered the Annual Address, entitled "The Beginnings of Sanitary Science and the Development of Sewerage and Sewage Disposal."

Following a report of the Tellers of Elections, the President declared the following elected as officers of the Club for 1911:

President: James Christie.
Vice-President: W. L. Plack.
Secretary: W. Purves Taylor.
Treasurer: F. H. Stier.
Directors: St. George H. Cooke, R. G. Develin, Richard Gilpin, J. A. Vogleson.

Mr. Easby then relinquished the chair to President Christie, who made a short address, accepting the Presidency of the Club. On motion of Mr. Hess, the thanks of the Club were extended to the officers of the Club for the year 1910.

Special Meeting, February 15, 1911.—The meeting was called to order by President Christie at 8.30 p. m., with about 300 members and visitors in attendance.

Lt.-Col. George W. Goethals presented the paper of the evening, entitled, "The Engineering Features of the Panama Canal," which was illustrated by a number of slides and by motion pictures. On conclusion of the paper the thanks of the Club were tendered to Colonel Goethals.

Regular Meeting, February 18, 1911.—The meeting was called to order by President Christie at 8.30 p. m., with 93 members and visitors in attendance. The minutes of the Special Meeting of the Club on Monday, January 30, and of the Annual Meeting of the Club on February 4, 1911, were approved as printed in abstract.

Mr. Henry H. Quimby, active member, presented the paper of the evening, entitled, "The Superstructure of the Passyunk Avenue Bridge," which was discussed by Messrs. John C. Trautwine, Jr., William Easby, Jr., William H. Ford, E. M. Nichols, Frank Burns and others.

Business Meeting, March 4, 1911.—The meeting was called to order by President Christie at 8.35 p. m., with 93 members and visitors in attendance. The minutes of the Special Meeting of February 15th and the Regular Meeting of February 18th were approved as printed in abstract.

The following amendments to the By-Laws were presented:

"We, the undersigned, hereby propose the following amendments to the By-Laws of this Club:

"1. Amend the first sentence of Section 2, of Article VI, Dues, by striking out 'of which $2.50 shall be set apart for the use of the Junior Section, payable on its

order,' making the sentence read: 'The annual dues of all resident active and associate members shall be $35; of resident junior members, $12.50; of non-resident active and associate members, $12.50, and of non-resident junior members, $5.00.'

"2. Strike out Article X, Junior Section."

(Signed) S. M. Swaab, Wm. Easby, Jr., J. A. Vogleson, M. M. Price, R. B. Owens, W. P. Taylor, James D. Faires, H. P. Cochrane, Manton E. Hibbs, Edgar P. Dout.

Two papers were presented: "The Design of Impellers of Modern Centrifugal Pumps," by Mr. N. W. Akimoff, Active Member, which was discussed by Messrs. Henry Hess, Robert Schmitz, James Christie and others; and "Engineering Features of Electric Furnaces," by Mr. Carl Hering, Active Member, which was discussed by Messrs. Henry Hess, C. H. Vom Baur, J. C. Parker and others.

Following a report of the Tellers, the President declared the following elected to membership: Active, Frank W. Van Loon; Associate, George N. Dawes; Junior, William Oram.

Regular Meeting, March 18, 1911.—The meeting was called to order by President Christie at 8.30 p. m., with 89 members and visitors in attendance. The minutes of the Business Meeting of March 4th were approved as printed in abstract.

Mr. B. A. Haldeman, Active Member, presented the paper of the evening, entitled, "A Review of the Progress of City Planning," which was discussed by Messrs. Leslie W. Miller, W. C. Furber, John C. Trautwine, Jr., James Christie and others.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Regular Meeting, January 19, 1911.—Present: President Easby, Vice-Presidents Christie and Hewitt, Directors Ehlers, Develin, Swaab, Mebus, Halstead, Worley, the Secretary, and the Treasurer. The minutes of the Regular Meeting of December 15th and the Adjourned Meeting of December 29th were read and approved.

Dr. Henry Leffmann and Mr. Edwin F. Smith, members of the Trustees of the Bond Redemption Fund, were present at this meeting of the Board by invitation, and the question of the revision of the method of retirement of the second mortgage bonds was discussed. Following this discussion, it was ordered that Section 4, paragraph A, of the method of redeeming Club bonds, as adopted at the regular meeting of the Board on March 21, 1908, reading as follows, "It will be the duty of the Treasurer of the Club to pay to the Trustees monthly all initiation fees dating from January 1, 1908," be suspended until otherwise ordered, and to take effect as of May, 1910. It was further ordered that, in accordance with the provisions of paragraph C of this section, $105 be appropriated to the Trustees of the Bond Redemption Fund.

The Treasurer presented a statement of the financial condition of the Club, showing a net gain for 1910 of $1287.86.

The Secretary reported that thirteen members of the Club had been dropped for non-payment of dues.

The resignations of D. W. Horn and James C. Wobensmith, Active Members, were read and accepted as of January 1, 1911.

The report of the Executive Committee was read, approved, and ordered to be printed as the Annual Report of the Board of Directors for the year 1910.

The Third Annual Report of the Trustees of the Bond Redemption Fund was also read, approved, and ordered printed with the report of the Directors.

Following an informal discussion on several Club matters, the meeting adjourned, upon motion, at 10 p. m., on the call of the chair.

Organization Meeting, February 7, 1911.—Present: President Christie, Vice-Presidents Hess and Black, Directors Hutchinson, Swaab, Wilson, Worley, Cooke, Develin, Gilpin, Vogleson, the Secretary, and the Treasurer.

The President then appointed the following to serve as standing committees for the ensuing year:

House: F. K. Worley, David Halstead, W. L. Plack, Richard Gilpin, W. P. Taylor.
Meetings: S. M. Swaab, Charles Hewitt, W. P. Taylor, J. A. Vogleson.
Membership: Charles Hewitt, Charles F. Mebus, R. G. Develin.
Finance: J. A. Vogleson, Henry Hess, Edward S. Hutchinson.
Publication: Charles F. Mebus, St. George H. Cooke, A. C. Wood.
Library: W. L. Plack, Richard Gilpin, E. J. Kerrick, P. H. Wilson.
Publicity: Henry Hess, David Halstead, F. H. Stier.
Advertising: R. G. Develin, H. F. Stier, P. H. Wilson.

The following were then elected by the Board to serve as Tellers and Auditors:

Tellers: Edwin M. Evans, E. J. Dauner, Alan Corson.
Alternate Tellers: G. Wise, Morton M. Price, Herbert Rice.
Auditors: W. B. Riegner, William C. Kerr, D. Robert Yarnall.

The following special committees were then appointed:

Committee on Increase of Membership: Wm. Easby, Jr., Chairman, Henry Hess, W. P. Dallett, H. H. Quimby, S. M. Swaab, D. Robert Yarnall. This committee was authorized to alter its membership, at its discretion.
Art Committee: W. L. Plack, Chairman, David Halstead, St. George H. Cooke.
Committee on Licensing Engineers: Dr. Edgar Marburg, Chairman, John Birkinbine, W. P. Taylor, was continued.

Mr. W. L. Plack, Chairman, S. M. Swaab, and J. A. Vogleson were appointed a special committee to consider and draft a resolution indorsing the efforts being made to establish uniform building laws throughout the United States.

Mr. Henry Hess, Chairman, J. A. Vogleson, and Richard Gilpin were appointed a special committee to consider ways and means for the formation of a committee to consider the standardization of engineering elements, said committee to report at the next meeting of the Board.

The salaries of the Secretary and Treasurer were fixed at $416 and $130 a year, respectively.

The Secretary presented an informal report on the financial condition of the Club.

Following the reading of a letter from Mr. S. H. Wright, relative to the Junior Section, it was ordered that a meeting of this Section be called for Saturday evening, February 18th, at 8 o'clock, to consider the future of the Section.

A letter from Mr. William R. Webster, relative to the licensing of engineers, was referred to the special committee of the Club on this subject, to report at the next meeting of the Board.

A letter from the Secretary of the Engineers' Club of Brooklyn, relative to an exchange of visits between the clubs of Brooklyn and Philadelphia, was read and referred to the entertainment division of the Committee on House, with the recommendation of the Board that these visits be arranged, if possible.

Mr. F. K. Worley was, upon motion, transferred from Associate to Active membership.

It was ordered that the regular meetings of the Board for the year 1911 be held on the Thursday evening preceding the third Saturday of the month.

Regular Meeting, March 16, 1911.—Present: President Christie, Vice-Presidents Hewitt and Plack, Directors Mebus, Swaab, Halstead, Worley, Cooke, Gilpin, the Secretary, and the Treasurer. The minutes of the Organization Meeting of the Board held February 7, 1911, were read and approved.

The Secretary presented a statement of the financial condition of the Club for the first two months of 1911, which showed a net gain in surplus of $239.74 for the two months.

A list of members delinquent in dues and house charges was read and, after discussion, the following resolution was passed:

"House charges incurred during any month are due on the first day of the month following. If these house accounts are not paid by the fifteenth of that month, the credit of the member will be stopped. If the account is not paid by the first of the following month, the member's name and the amount of his obligation will be posted on the bulletin board. There will be positively no exception to this rule."

It was further ordered that all members delinquent in payment of dues be posted in the Club-house two months after the delinquency is incurred, unless extension of time for payment shall have been granted by the Board. It was further ordered that this resolution be printed and sent to each member of the Club.

Messrs. J. W. Mackay and Henry Longcope were dropped from the rolls for non-payment of dues.

The following resignations were read and accepted: Alfred Kauffmann, A. B. Eddowes, M. M. Borden, Adam Laidlaw, E. R. Snyder, O. M. Milligan, F. C. Hubley.

A letter from Mr. Herbert Rice, declining the election to office of Alternate Teller, was read and accepted. Mr. L. R. Ferguson was then elected Alternate Teller in his place.

A letter from Dr. Henry Leffmann, Chairman of the Trustees of the Bond Redemption Fund, was read and ordered to be filed.

A letter from the Chairman of the Convention Section of the Engineers' Society of Pennsylvania, asking whether the Engineers' Club of Philadelphia desired to organize a Convention of this Society for the coming year, was read, and it was decided that this Club did not desire this Convention this year.

A report of the Committee on the Licensing of Engineers was read, and it was ordered that action in this matter be deferred until the Joint Committee of the Pennsylvania Engineering Societies had presented its recommendations.

A letter from the President of the Chamber of Commerce of Pittsburg, requesting action of the Club on certain bills before the State Legislature, was read, and it was decided that no action in this matter should be taken.

The Committee on House was authorized to solicit and collect subscriptions for a Ladies' Night, to be held April 24, 1911, and the Chairman of the Committee on House was authorized to increase his Committee by appointment of not more than two members.

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXVIII. JULY, 1911. No. 3

PAPER NO. 1098.

NEW YORK CITY'S ADDITIONAL WATER SUPPLY FROM THE CATSKILL MOUNTAINS.

THOS. H. WIGGIN.
(Visitor.)

Read January 7, 1911.

A NEW aqueduct for New York City, capable of carrying more than 500,000,000 gallons daily, is under construction for the entire distance from the Catskill Mountains to the New York City line. A storage reservoir (Ashokan) in the Catskills, having a capacity of 130,000,000,000 gallons, or 250 days' supply for the whole City of Greater New York; another storage reservoir (Kensico), nearer the City, with a capacity of 40,000,000,000 gallons; and a distributing reservoir (Hillview), with a capacity of 900,000,000 gallons, are also under construction. Drawings and specifications for a deep tunnel extending the Catskill aqueduct through Bronx and Manhattan boroughs and into Brooklyn are ready for advertisement; and contracts for large pipe lines for carrying the new supply into the borough of Queens, Brooklyn, and Richmond, with a regulating reservoir in the latter, are partially prepared and will be let in time to receive the water from the tunnel, which will be of slower construction.

The total length of main aqueduct from Ashokan reservoir to Brooklyn is 110 miles, and the conduits through Queens, Brooklyn

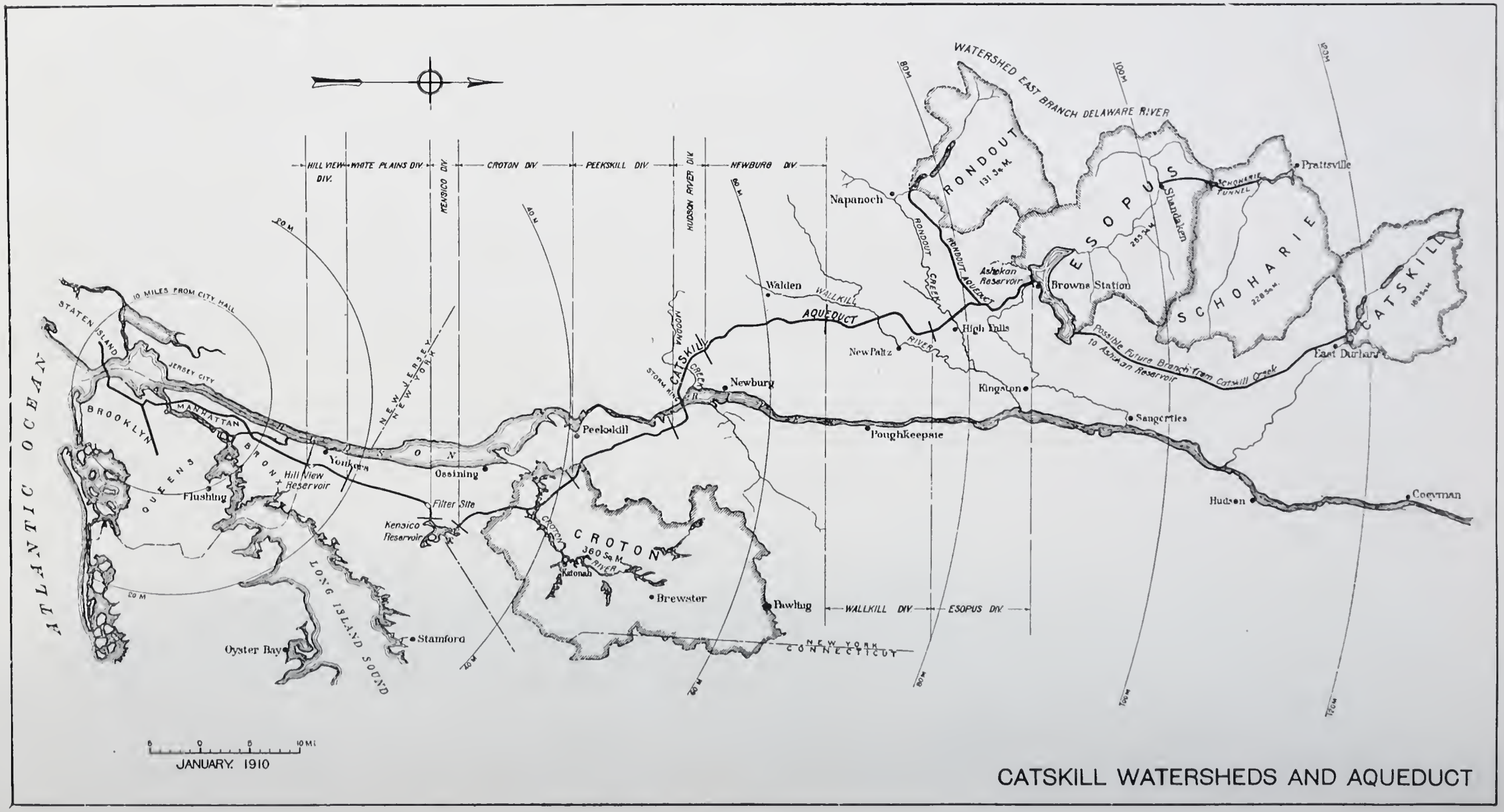

CATSKILL WATERSHEDS AND AQUEDUCT
JANUARY 1910
WATERSHED EAST BRANCH DELAWARE RIVER
HILL VIEW DIV.
WHITE PLAINS DIV.
KENSICO DIV.
CROTON DIV.
PEEKSKILL DIV.
HUDSON RIVER DIV.
NEWBURG DIV.
WALLKILL DIV.
ESOPUS DIV.
10 MILES FROM CITY HALL
ATLANTIC OCEAN
STATEN ISLAND
JERSEY CITY
BROOKLYN
MANHATTAN
QUEENS
BRONX
NEW JERSEY
NEW YORK
LONG ISLAND SOUND
Flushing
Hill View Reservoir
Yonkers
Ossining
Filter Site
Kensico Reservoir
Peekskill
Oyster Bay
Stamford
CROTON
360 Sq. M.
Katonah
Brewster
Pawling
CATSKILL
WOODBURY
STORM KING
Newburg
Walden
WALLKILL
AQUEDUCT
New Paltz
Napanoch
RONDOUT
131 Sq. M.
RONDOUT CREEK
RONDOUT AQUEDUCT
Ashokan Reservoir
Browns Station
High Falls
Kingston
Poughkeepsie
ESOPUS
Shandaken
SCHOHARIE
228 Sq. M.
SCHOHARIE TUNNEL
Prattsville
Possible Future Branch from Catskill Creek to Ashokan Reservoir
East Durham
Hudson
Coeymans
NEW YORK
CONNECTICUT

Fig. 1.

and Richmond comprise 16 miles of pipe line, generally 66 inches in diameter, making a grand total of 126 miles. The total amount of the contracts for doing this work will probably be about $100,000,000, of which $71,000,000 is for work already under construction. Land and engineering and other contingent expenses are not included in this cost.

The work above referred to will provide an aqueduct of more than 500,000,000 gallons daily capacity,* but watershed capacity of only about 250,000,000 gallons daily. To complete the scheme sufficiently to use the aqueduct approximately to its full capacity, two other Catskill watersheds must be connected, viz., Rondout and Schoharie. Two main additional reservoirs of a combined capacity of about 40,000,000,000 gallons and two branch aqueducts aggregating upwards of 20 miles will be necessary to develop these sources. The cost of these additions is estimated at about $25,000,000.

The date at which the first addition will be needed depends on several factors which are difficult to predict. Thus all the present Brooklyn supply is pumped from wells at a large cost. Catskill water, once made available and not needed elsewhere, can be supplied to Brooklyn without cost, and it might be found cheaper, so long as the Catskill aqueduct remained adequate, to build some of the additional works in the Catskills earlier rather than pay cost of pumping in Brooklyn during the intervening period. Moreover, certain of these ground-waters have become too saline by overdraft.

Again, there is a large supply of ground-water in the eastern two-thirds of Long Island which remains undeveloped by reason of local opposition to enabling legislation. This water was by far the quickest available for New York City, and, with power, the Board of Water Supply would have developed it first to minimize danger of water famine. A removal of the legal obstacle to Long Island development might affect the date of additional Catskill development. Without further Long Island development the second Catskill source would be needed in about 1918, to give assurance of sufficient capacity to withstand a series of dry years.

The Catskill scheme includes provisions for constructing a filter plant whenever it seems advisable. A site has already been purchased, and a gate chamber is provided on the Catskill aqueduct for intercepting the flow and shunting the water to and from the filters.

* Except for about 6 miles of steel pipe siphons across valleys, where, for the purpose of deferring cost, only one pipe line, out of three lines required for the total capacity, is to be installed at present.

The cost of the whole scheme, including development of the enumerated additional watersheds and the filters, land, engineering, and contingencies, is estimated at about $175,000,000.

Need for Additional Supply.

The average citizen of New York City, educated by long years of promiscuous mud-slinging, and without means of distinguishing trustworthy from untrustworthy sources of information, would probably say, if asked, that the need of an additional supply was largely a financial one, felt by politicians, contractors, and engineers. Nature has been against a vindication of the opinion that the city is in danger of a water famine, in that, with the exception of a few isolated years, she has sent unusually high rainfall since the necessity was first preached. All engineering computations as to adequacy of an existing water supply turn not on records of high rainfall and run-off, but on records of various series of dry years that have been experienced in the period for which records are available. Even this test fails in conservatism because no thinking person can fail to recognize that nature has in store drier periods, as well as wetter ones, than she has produced during the forty years for which records are available. Engineering structures are planned with a factor of safety. Most structures would actually stand without destruction under at least twice the maximum load which it is expected they will ever be called upon to bear. The reckoning as to need for additional water supply provides *no* factor of safety. The writer computed in 1906 that if any one of several series of dry years which had occurred since 1868 should repeat themselves, the existing reservoirs would become absolutely dry in less than two years.

In other words, New York City is dependent on a supply which is already taxed beyond the theoretical breaking-point. Some might ask, can not the supply be throttled and economy compelled when danger threatens? A little, yes, but much only after it is too late, since hope of rain is always present in a dry time. In 1883 before the new Croton system was completed, there was actually only one day's supply left in New York City's reservoirs when rain came. The dry weather flow of Croton River is not more than one-tenth the average draft from the reservoirs: that is, nine-tenths the supply would be suddenly cut off if the reservoirs were emptied in dry weather.

But the battle of convincing a citizen of New York City of the necessity for the Catskill supply is not over when one has convinced

him of the inadequacy of the Croton system. One paper of considerable influence repeatedly shows pictures of water spilling over the existing Croton dam in spring, and explains how millions of dollars are being wasted in what it is pleased to call "the Catskill steal," alleging that much smaller sums spent in additional reservoirs on the Croton watershed would enable the escaping floods to be corraled and render said steal unnecessary. This allegation can be made in a newspaper headline so clearly that a whole city can understand it without even buying the paper, but an adequate answer to it, put with admirable conciseness, took more than three pages in "Engineering News."* It is therein shown by careful analysis that an expenditure of $150,000,000 for additional reservoirs would add only 47,000,000 gallons to the safe daily capacity, whereas the same expenditure on the Catskill supply will produce over 500,000,000 gallons additional daily.

Without duplicating the article referred to, a few facts may serve to make the conclusion more concrete that Croton watershed is already thoroughly developed. The average run-off for the years 1868 to 1909 inclusive was about 400,000,000 gallons daily, or 23.5 inches if reckoned on the whole watershed of 360 square miles. The run-off during the eighteen years 1869 to 1886 inclusive was low, averaging only 346,000,000 gallons daily (20.2 inches), or only 10,000,000 gallons daily in excess of the latest estimated safe yield (336 M.g.d. = 19.6 inches). The run-off during the next eighteen years, 1887 to 1904 inclusive, was generally high, averaging 449,000,000 gallons daily (26.2 inches). Evidently to increase the safe yield from 19.6 inches, now assumed, to the average of 23.5 inches run-off from 1868 to 1909 inclusive, would require at least storage enough to impound all the surplus in a period like that from 1887 to 1904, for subsequent use in a period like that from 1869 to 1886. This surplus is about 46 inches. The total storage capacity of reservoirs now on Croton watershed is only about 16.7 inches (104.5 billion gallons). These figures, dealing with only one of the factors entering into the figure for total storage, would indicate that at least triple the present storage would be required to add one-fifth to the safe yield. Moreover, evaporation from this enormously increased reservoir surface would largely reduce the assumed possible one-fifth gain in safe yield. The precise figures given in the article above

* See article by A. D. Flinn, Dept. Engr., Board of Water Supply, "Engineering News," Feb. 6, 1908, pp. 155–157, and June 17, 1909, p. 650.

referred to, indicate 65 inches total storage required to increase the safe yield 47,000,000 gallons daily, or 14 per cent. Imagine the chagrin if eighteen dry years should follow the installation of these mighty reservoirs. But explanations to the average citizen are futile, owing both to the necessary complication of such explanations and to his lack of faith in anything governmental. The only vindication the engineers could have would be the repetition of some of the passed series of dry years. Such a vindication, carried only to the safe point, one cannot refrain from wishing for in moments of extreme annoyance at the stupid or malicious attacks on the scheme.

The first relief from the new source will come in 1913 if no contractor whose work is at a limiting point fails markedly in his guaranteed progress. The extensions through the City, which are necessary in order to do more than guarantee the continuation of the present supply, cannot be completed until the middle of 1915 if started at once and prosecuted without unusual delays. These contracts are now awaiting the approval of the City's legal department as to form.

The press stated that the contracts were advertised before completion, and that they contained provisions which could be interpreted in an unduly favoring way in case the proper contractor was concerned. Having been in direct charge of designs and specifications for this work, the author can testify that drawings and pamphlets were complete and that specifications were and are absolutely similar—except for necessary minor variations to suit different conditions—to all specifications for six similar pieces of work, aggregating 18 miles of tunnel, already under construction. The specifications for the Catskill project are as explicit as they can be made for so varied a work without compelling the engineer to stultify himself by violating them to meet unforeseeable conditions, or to avoid absurd requirements. In most cities indeterminate parts of a work might be done at cost plus a percentage, but counsel for New York City will not approve such a provision, and fantastic items have occasionally to be resorted to in the attempt to include under bid prices every conceivable contingency. No new fantasies have been invented, however, for these contracts.

History.

The need of an additional supply was first brought into prominence in 1899 by a movement variously styled the "Ramapo scheme" or "Ramapo steal." A band of men proposed to develop the Ramapo

watershed, a shed of about 119 square miles, which is west of the Hudson River about opposite Croton, and sell water to the city. This scheme was successfully opposed on financial and other grounds by Bird S. Coler, then Controller, aided by the Merchants' Association, Chamber of Commerce, and other bodies. The report on the whole New York supply made to Mr. Coler by Mr. John R. Freeman, who was employed by the former, is one of the most valuable ever written, and is invaluable to the student of New York city's waterworks. Mr. Freeman points out, among other things, the cheapness and plentifulness of a supply from the Hoosatonic River, but this scheme, though much cheaper than the Catskill, has never been actively pushed because a part of the shed is in Connecticut, thus involving an interstate arrangement.

The next important move was the appointment, in the Seth Low administration, of the Commission on Additional Water Supply, consisting of Prof. Wm. H. Burr, of Columbia University, Rudolph Hering, and John R. Freeman. This commission employed a large force of engineers during most of 1903, and recommended a supply drawn at first from the watersheds of Fishkill Creek, Wappinger Creek, and Roeliff Jansenkill in Putnam County, extended as necessary to the Esopus watershed in the Catskills. Reservoirs and a 500-million gallon aqueduct with branch feeders at its northern end, also a filter plant at Stormville, N. Y., near Fishkill Creek, were planned, and surveys, drawings, and specifications of a general nature well advanced, when the defeat of the Low or Citizens' Union administration and the election of the McClellan or Democratic administration stopped the work. An act of legislation was then passed at the behest of the people of Dutchess County forbidding New York City to take water from Dutchess County. It may be said, in passing, that if indications are trustworthy these same people are now sorry they objected, witnessing the profitable land sales and active business that have come to their friends across the Hudson.

Through the vigorous action of Mayor McClellan and the continued interest of the Merchants' Association, the Chamber of Commerce and other enlightened (and, it may be admitted for the satisfaction of the average citizen's pessimism probably some not wholly disinterested) persons, the present non-partisan Board of Water Supply was created by the legislature on June 3, 1905. Mayor McClellan at first desired a provision in the act which would place the appointing power in the hands of the Chamber of Commerce, Manufacturers'

Association, and Board of Fire Underwriters, but this proved impracticable. On June 9, 1905, he appointed as Commissioners J. Edward Simmons, Charles N. Chadwick, and Charles A. Shaw, from three lists of three names each, submitted by the above mentioned bodies. Mr. Simmons resigned, and was succeeded by John A. Bensel in 1908. Chief Engineer J. Waldo Smith reported for duty August 1, 1905. Mr. Bensel resigned December 31, 1910, to become State Engineer.

October 9, 1905, four months after its creation, the Board of Water Supply submitted to the Board of Estimate and Apportionment a plan for obtaining from Esopus, Rondout and Schoharie Creeks, a supply of not less than 500,000,000 gallons of water daily, at an estimated cost of $161,857,000. Unanimous approval was given by the Board of Estimate and Apportionment October 27, 1905, and November 3, application was made to the State Water Supply Commission for approval, as required by law. May 14, 1906, this approval was granted, and in less than six months the first construction contract was let, for 11 miles of aqueduct. The present state of the work was described at the beginning of this paper. Completion of the plan for delivering water in New York city increased the original estimate $15,000,000, the plan of 1905 having included only a part of the delivery system.

Description of the Catskill Works.

Ashokan Reservoir.—Ashokan reservoir, greatest of the storage reservoirs required for the Catskill scheme, is now being built under contracts amounting to nearly $14,000,000. The following statistics will most briefly convey an idea of its size and of the problem of construction:

Capacity	130,000,000,000 gallons
Water surface	8,180 acres = 12.8 sq. m.
Land required	15,222 acres
Elevation of water	590 feet above tide
Elevation of tops of dams	610 feet above tide
Length of reservoir	12 miles
Length of shore line	40 miles
Lengths of dams and dikes	5½ miles
Maximum width of reservoir	3 miles
Average width of reservoir	1 mile
Maximum depth of reservoir	190 feet
Villages to be submerged	7
Population of villages	2,000
Cemeteries to be removed	32
Bodies in cemeteries	2,400

Railroad to be relocated.....	11 miles
Highways to be discontinued..	64 miles
Highways to be built.....	35 miles
Bridges to be built.....	9 miles
Material to be excavated	2,468,000 cu. yds.
Embankment to be placed	8,025,000 cu. yds.
Masonry to be placed.....	820,000 cu. yds.
Number of men employed.....	3,000

Ninety billion gallons of the capacity of Ashokan reservoir is sufficient to furnish storage for the development to an economic point * of the Esopus watershed. The balance of its capacity will form a part of the storage for Schoharie watershed, since this part of its necessary storage can be obtained more cheaply by an excess in size of Ashokan reservoir than by a larger reservoir on that shed. The Ashokan reservoir may be used also to help out the storage on the Rondout and Catskill sheds by temporarily increasing the proportion of water drawn into the main aqueduct from those sheds.

Olive Bridge Dam.—The most important structure of the reservoir is Olive Bridge dam, the length of which is about 4800 feet, including 1000 feet all masonry and 3800 feet earth with masonry core wall. The maximum height of the masonry dam from bed-rock to top is 220 feet, not including a cut-off wall about 20 feet wide, which extends about 40 feet deeper. The masonry dam, like that at Boonton, N. J., and at Cross River and Croton Falls on the Croton shed, all built under Mr. J. Waldo Smith, is built of so-called Cyclopean masonry faced with concrete blocks. Fig. 2 shows a cross-section and Fig. 3 shows the comparative section of this and certain other well known dams. The comparatively liberal dimensions of Olive Bridge dam are due to assumption of an ice-pressure of 47,000 pounds per linear foot of dam and of upward water-pressure on two-thirds the area of horizontal planes, and varying from 0 at the toe to full head at the heel of the dam.

The most notable details of construction are the complete interior drainage above the level of the fill on the down-stream side and the use of expansion joints at intervals, generally 84 feet. The drainage is accomplished by embedding, 12 feet apart, in a nearly vertical plane about 15 feet from the up-stream face of the dam, stacks consisting of blocks of special porous concrete 3 feet square with an 18-inch hole in each, together forming in each stack a continuous nearly vertical hole 18 inches in diameter. These holes terminate

* Development is very high, viz., ten-year depletion basis, on account of cheapness of storage in Ashokan reservoir.

at their tops and at their bottoms in a gallery about 5 feet by 7 feet, running the whole length of the masonry dam, and designed for use in inspecting the drainage system and the expansion joints. The expansion joints contain three distinct lines of resistance to leakage: (a) the usual dovetailings, consisting of several broad but shallow keys and grooves with distinct "draw"; (*b*) a copper strip bridging

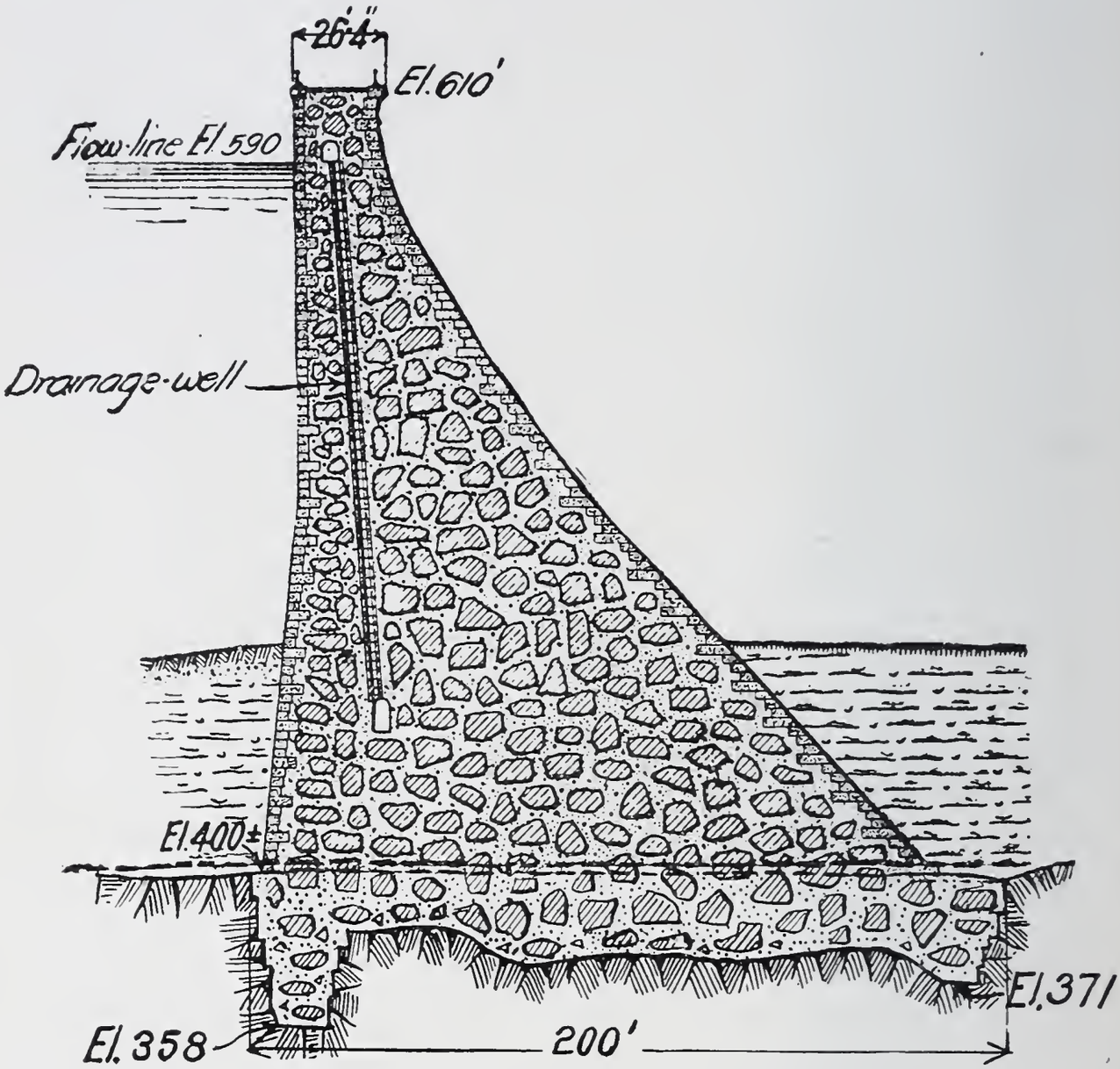


Fig. 2.—Olive Bridge dam; maximum masonry section.

the crevice, but bent so as not to be torn by shrinkage of concrete; (*c*) a well, to be at first used in connection with the galleries above described for inspection of the effectiveness of the two first lines of resistance, and finally, if necessary, to be filled with concrete to decrease the leakage.

In addition to the Olive Bridge dam, dikes of an aggregate length

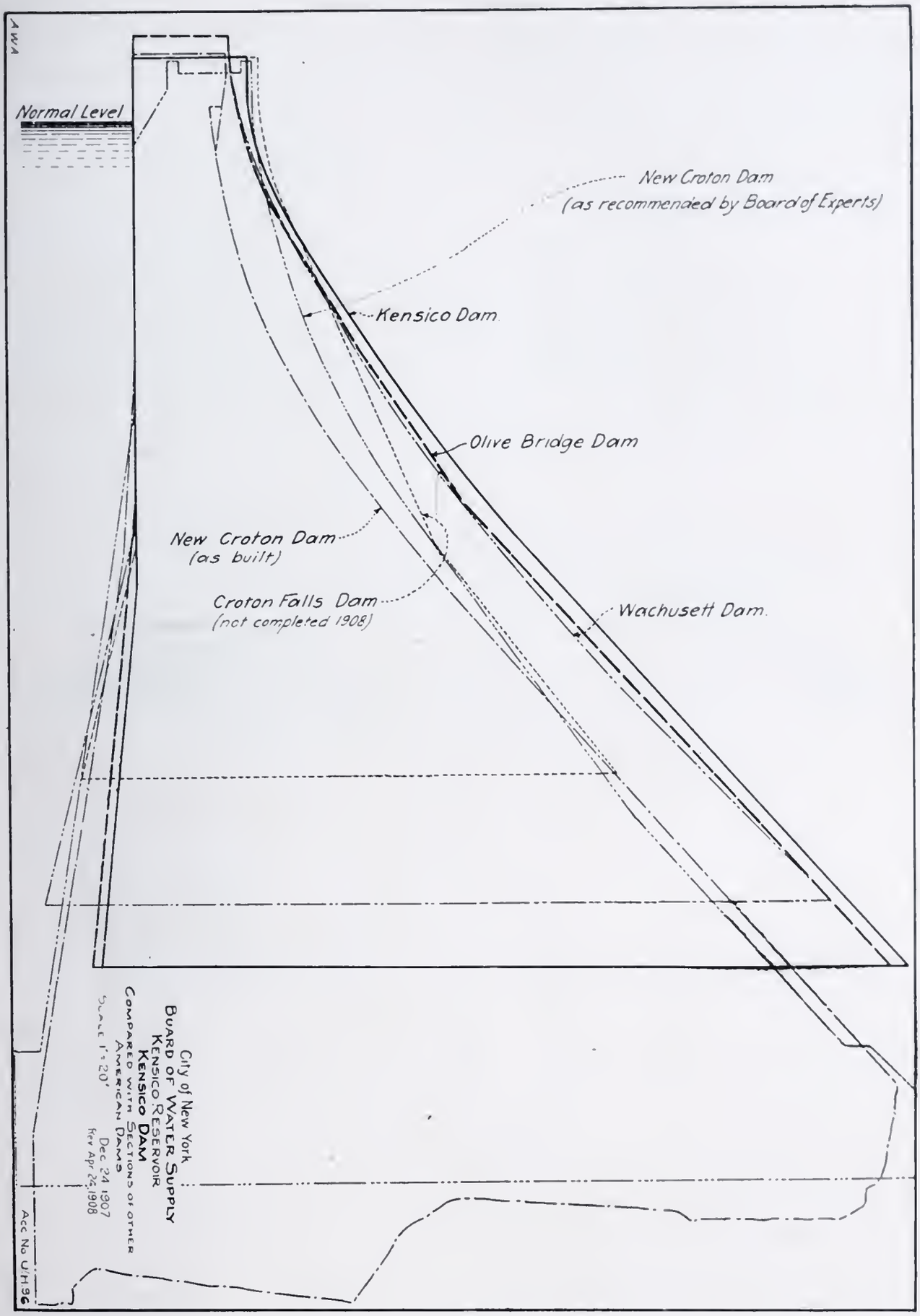

Normal Level
New Croton Dam
(as recommended by Board of Experts)
Kensico Dam
Olive Bridge Dam
New Croton Dam
(as built)
Croton Falls Dam
(not completed 1908)
Wachusett Dam
City of New York
Board of Water Supply
Kensico Reservoir
Kensico Dam
Compared with Sections of other
American Dams
Scale 1"=20'
Dec. 24 1907
Rev Apr 24, 1908
Acc No U/H 96

Fig. 3.

of about 4½ miles are required to complete the outer shore line. These dikes are rather sizable dams in themselves, the Beaver Kill dike having a height of 100 feet above the original earth surface, with a core wall extending 80 feet deeper to rock. Fig. 4 shows the general type of construction. The concrete core wall is used except where the dike is less than 20 feet high, *i. e.*, except where the base is above the flow line.

The rock at the Ashokan reservoir is bluestone and shale with nearly horizontal stratification. Careful grouting of the seams was found advisable at the Olive Bridge dam. The earth is largely rock flour with boulders, sometimes called hard pan, and makes excellent embankment. A pocket of sand in a "buried gorge" created the necessity for the deep Beaver Kill dike.

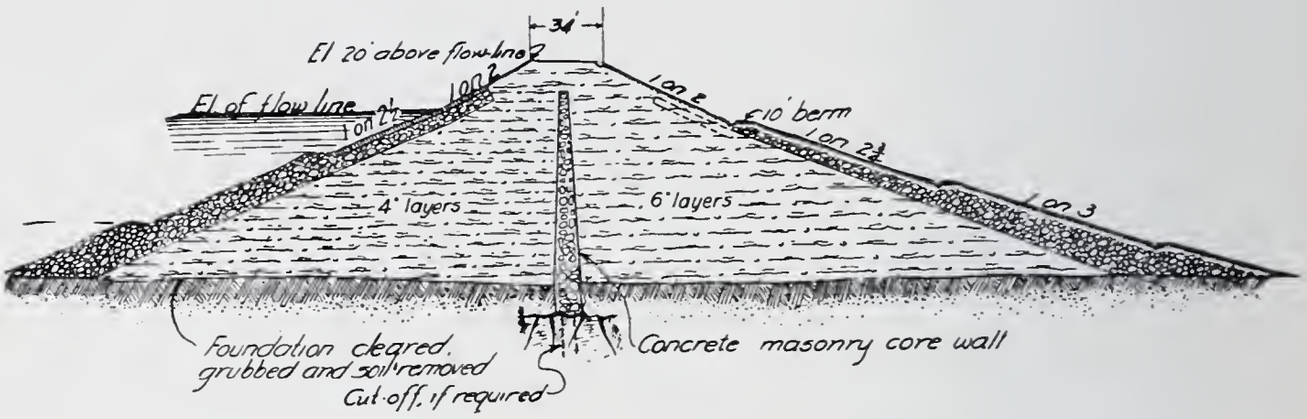


Fig. 4.—Typical section of dike.

Ashokan reservoir is almost divided into two parts by the topography, and this division is being completed by construction. The total length of artificial division is about 2000 feet, of which about 1000 feet is a masonry overfall section. The spillway is in the east basin, and has a length of 950 feet and a capacity of 50,000 cubic feet per second, flowing about 5.5 feet deep. This is equivalent to a little under 200 cubic feet per second per square mile.

Kensico Reservoir.—Ashokan reservoir is connected by an aqueduct passing under the Hudson River and 77 miles in length, with Kensico reservoir, which is 30 miles from City Hall. This reservoir, which is now being built under contracts aggregating nearly $8,500,000, has a capacity of 40,000,000,000 gallons, of which about 28,000,000,000 gallons can be run, without pumping and at full or nearly full rate, into the aqueduct southerly. Statistics follow:

KENSICO RESERVOIR.

Total capacity	40,000,000,000 gallons
Capacity available without pumping	28,000,000,000 gallons
Water surface	717 acres
Land required	3,184 acres
Elevation of water	355 feet above tide
Maximum depth of water	155 feet
Elevation of top of dam	370 feet above tide
Maximum height of dam	290 feet
Width of top of dam	28 feet
Maximum width of dam	230 feet
Length of dam	1,830 feet
Materials to be excavated	957,000 cu. yds.
Embankment to be placed	1,188,000 cu. yds.
Masonry to be placed	983,000 cu. yds.
Amount of Kensico dam contract	$7,953,000
Highways to be discontinued	16 miles
Highways to be built	9 miles
Bridges to be built	4 miles

Kensico reservoir is so large as materially to simplify the problem of cleaning and repairing the aqueduct north and give security against interruption of supply from any but the most serious and practically unheard-of accident.

The main feature of the reservoir is the Kensico dam, 1830 feet long, and estimated to be 290 feet high at its maximum, not including cut-off wall. The excavation has not progressed yet, as the dam lies across what is now Kensico Lake, forming a part of the present supply for New York City, and temporary diversion works must first be completed. Kensico dam, being in the midst of the populous and growing suburban territory of Westchester County, will be made of more ornamental construction than the Olive Bridge dam at Ashokan reservoir, and the down-stream side will be faced with granite instead of with concrete blocks. The excess cost above that of a dam like that at Ashokan reservoir is about $750,000. The Kensico dam has the same special features for drainage and expansion joints as has the Olive Bridge dam.

Hillview Reservoir.—From Kensico reservoir there are 15 miles of aqueduct to Hillview reservoir, which is not far from the north boundary of the City.

Its function will be to equalize the differences between the use of water in the City as it varies from hour to hour and the steady flow in the great aqueduct, and to furnish large quantities of water upon immediate demand, as in a great conflagration. It will hold 900,000,000 gallons. The contract was let for $3,270,000. It is divided into two parts and a by-pass aqueduct is formed by a 12-foot

circular void in the concrete division wall. The embankments are very wide, as a result of the large quantity of excavation required on that hill-top site to give the desired capacity with the minimum expenditure for construction and land, the latter being a large factor in that neighborhood. The great security afforded by these massive embankments in not inappropriate on account of the large population which is or will be housed around the site on lower land.

Head-works of the Aqueduct.—The upper effluent gatehouse at Ashokan reservoir, about 80 by 125 feet, is located in the dividing weir and has provisions for drawing from either basin at any desired level. The lower effluent gatehouse is connected with the upper by two masonry conduits, each having an area of about 120 square feet, built one over the other in a rock trench and designed to withstand a head up to the level of the reservoir flow line. The throttling control thus may be, and is designed to be, at the lower gatehouse, which has a superstructure about 50 by 140 feet and considerable substructure buried below ground. Fig. 5 shows a special control gate of the needle type to avoid vibration and wear of the masonry by eddies. In the lower gatehouse will be a turbine and generator for developing 125 K. W., to be used in operating gates and for local lighting; a pit for a duplicate 125 K. W. unit is also provided. Just up-stream from the lower gatehouse plugged outlets are left on the aqueduct to permit the convenient extension of a by-pass aqueduct to a large power plant, contemplated in case conditions justify it at some future time. In the lower gatehouse will be installed a central heating plant. Adjacent, but not covered by the superstructure, is a large coal pocket.

The aqueduct continues double beyond the lower gatehouse as far as the screen chamber. Up-stream from the screen chamber is a waste weir on each aqueduct, the two having a total length of crest of about 100 feet. The double aqueduct permits wasting from either basin of Ashokan reservoir while drawing the water supply from the other basin, and the weirs are so proportioned as to prevent putting the aqueduct down-stream from the screen chamber under more than 3 feet head by any conceivable stupidity in opening the headworks gates.

The screen chamber is about 60 by 115 feet. It and all the headworks described are designed for a flow double that which the Catskill aqueduct can take, and the screen chamber has a plugged outlet from which the second aqueduct can be extended to the City when needed. The screen chamber is separable by stop-planks into two similar parts so that each could serve one aqueduct to the City,

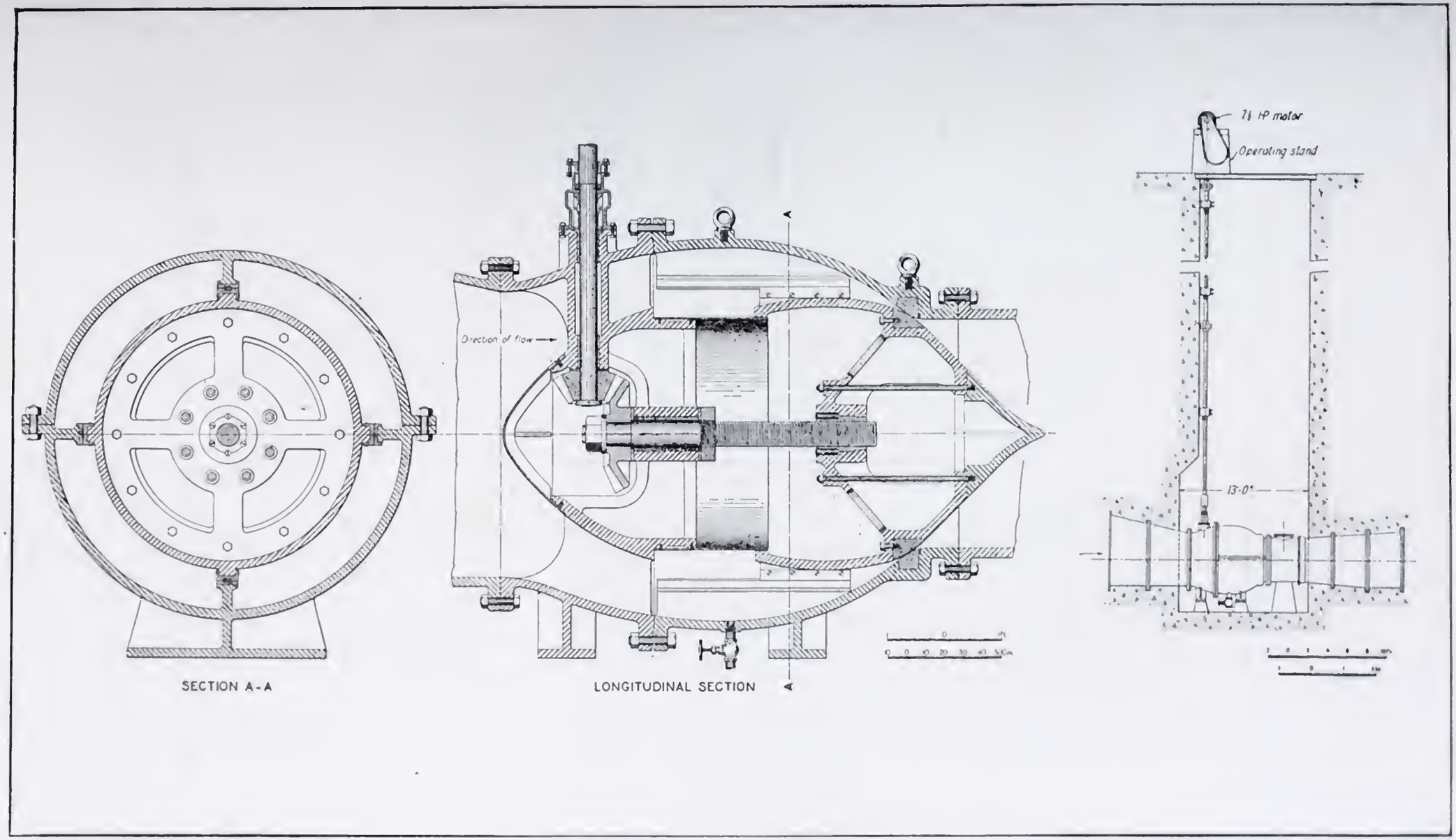


FIG. 5.—Special control gate of the needle type.

though both will be available for the first aqueduct. The chamber is of very liberal size and contains an ingenious arrangement of screen grooves which permit a greatly increased area of screens for use during the short period when leaves are troublesome. With two aqueducts of the size of the Catskill aqueduct flowing at full capacity, the velocity through the gross area of screens as usually to be placed would be about 1.8 feet per second; with the increased area, an average of about 0.8 feet per second; and through the minimum passages 2.6 feet per second. Screens of special design are placed temporarily in these minimum passages, down-stream from such of the main screens as are being pulled for cleaning. The screens will probably have a clear mesh opening of ¼ inch or ⅜ inch square. Coarse debris is kept out of the aqueduct by racks over the inlets to the upper gate-house.

Aëration Works vs. Treatment of Reservoir Bottoms at Ashokan and Kensico Reservoirs.—Unlike the great Wachusett reservoir of the Boston Metropolitan District water supply, the Ashokan and Kensico reservoirs will not be entirely stripped of vegetation and soil. At Ashokan, besides clearing of trees and shrubs, swamps will be drained and burned over, and in shallow flowage areas probably stripped or covered with earth that is practically free from vegetable matter. At Kensico reservoir, swamps will all be either stripped or covered with at least one foot of earth. In both reservoirs, areas of very shallow flowage will generally be filled in. Reservoirs will be burned or cut over just previous to filling. The Board's biological experts, Messrs. Geo. W. Fuller and Allen Hazen, recommended aëration works and a filter plant as more effective than the usual stripping, and moreover permanently effective investments. Fig. 6 shows an artist's sketch of the large area (nearly two acres) of spraying nozzle in action as contemplated. With full reservoirs, a head of about 90 feet at Ashokan and of 30 feet (40 feet previous to installation of filter plant) at Kensico reservoir are available for the spraying. The aëration plants are on by-passes which begin and are controlled at the lower effluent gatehouses and join the aqueduct again up-stream from the screen chamber. Thus the aëration plants may be cut out completely at will.

Aqueduct Control Works at Kensico Reservoir.—The aqueduct discharges into Kensico reservoir in its northeasterly portion over a weir 180 feet long, just up-stream from the influent gatehouse, in size about 32 by 42 feet. At this gatehouse begins the by-pass aqueduct, 2¾ miles long, and gates are provided which, when closed,

compel the water to pass over the weir into the reservoir, and, when open, permit the water instead to flow through the by-pass aqueduct, thus cutting out the reservoir.

At the southwesterly part of the reservoir, partly within the flow line, is the upper effluent gate-chamber, in size about 48 feet square. An inlet channel about 800 feet long leads to this gate-chamber, heavy cutting being required to permit the reservoir to be drawn sufficiently low. Racks are placed on the outer wall over the openings leading to the gates. The by-pass aqueduct leads into this gatehouse down-stream from the gates and, from the same portion, the effluent aqueduct extends as a masonry-lined rock tunnel 17 feet high by 13 feet 4 inches wide through a divide, a distance of about 1150 feet, to

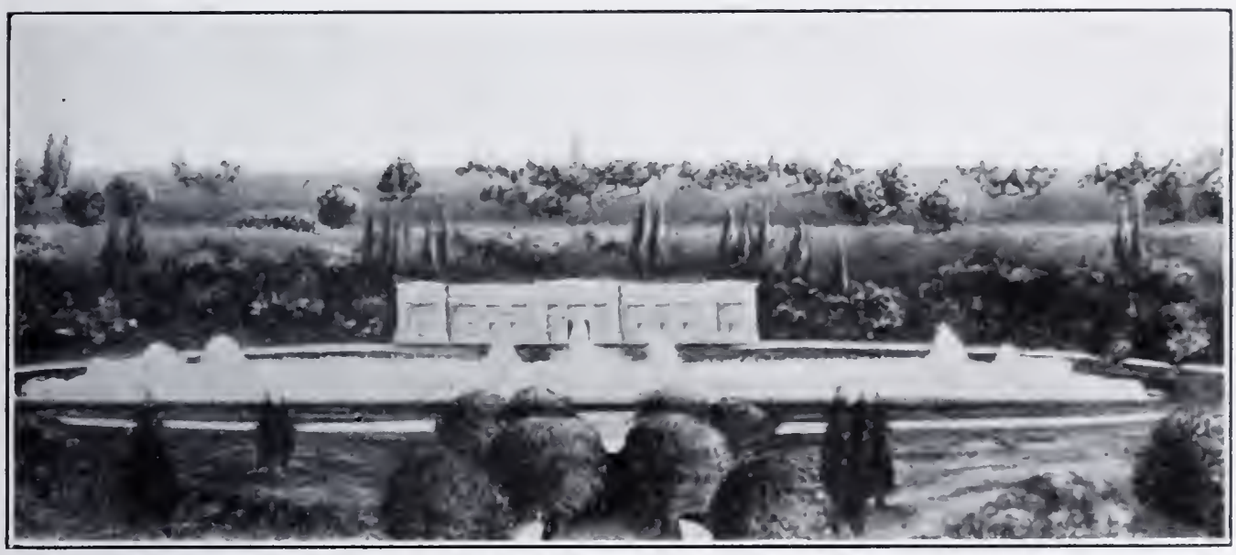


Fig. 6.—Aëration, gatehouse and dike, Ashokan Reservoir.

the lower effluent gate-chamber. The latter is about 72 feet by 92 feet, a large chamber combining many functions. As in the case of Ashokan reservoir, the throttling control of Kensico reservoir outlet is at the lower effluent gate-chamber. In it also are gates controlling the aërator by-pass, a 125 K. W. generator for local power and lighting, and provisions for three additional generators of 500 K. W. each. This power, unlike that at Ashokan reservoir, is so near New York City that it is hoped that it may be profitably used for lighting a near portion of the City or for operating high service pumps.

A screen chamber, about 50 feet square and designed on the same liberal lines as that at Ashokan reservoir, is located about 600 feet down the aqueduct from the lower effluent gate-chamber. The aëration plant is adjacent to this lower effluent chamber, and the aqueduct

flowing from the aërator joins the main aqueduct about 200 feet upstream from the screen chamber.

Gatehouses at Hill View Reservoir.—At the ends of Hill View reservoir are situated respectively the influent gate-chamber, about 64 by 104 feet, and the effluent gate-chamber, about 88 by 120 feet. The Catskill aqueduct proper leading to the reservoir and the aqueduct leading to the City are here both in deep tunnel under pressure, and connect respectively with the influent and effluent gate-chambers by vertical shafts located within the areas of the chambers. The influent and effluent chambers are each so arranged and so supplied with sluice gates as to permit flow respectively into and out of one or both basins of the reservoir or the by-pass aqueduct which has its termini at these chambers.

Catskill Aqueduct.

Returning now to the Catskill aqueduct and its City extensions, so great a variety of types and sizes are met with as to defy adequate description within the compass of this paper. The following table will most briefly convey an impression of the whole:

STATISTICS OF CATSKILL AQUEDUCT.

I. Catskill Aqueduct Proper.

(A) Ashokan Reservoir to Influent Gate-chamber at Kensico Reservoir.

	Miles	Miles	Miles
1. Special double aqueduct at headworks	0.25	..	..
2. Plain concrete horseshoe aque. 17′ high x 17′ 6″ wide in open cut and on embank. ("cut and cover" aqueduct)	43.6	..	..
3. Similar to 2, but reinforced for about 15′ head* in siphon. (Reinforcement nominal—masonry designed massive enough to carry load to sides of trench, which are rock)	0.06	..	..
4. Reinforced concrete siphon 16′ 0″ diam., 35′ max. head*	0.12	..	..
5. Reinforced depressed aque. containing Venturi meters, 17′ 6″ to 7′ 9″ diam., 20′ max. head*	0.16	..	..
6. Tunnel at hydraulic gradient ("grade tunnel"), horseshoe 17′ 0″ high x 13′ 4″ wide	11.2	..	..
7. Tunnel below hyd. gradient ("pressure tunnel"): 14′ 6″ diam. = 8.9; 14′ 2″ " = 4.8; 14′ 0″ " = 1.2	14.9	..	..
8. Riveted steel pipe, concrete-covered and mortar-lined: steel shell 9′ 6″ diam. = 3.6; " " 9′ 9″ " = .7	4.3	74.6	..

* Maximum head measured to intrados of arch at crown.

(B) Kensico By-pass.

	Miles	Miles	Miles
1. Reinforced concrete aqueduct, 11′ 0″ diam., 35′ max. head*	2.2	..	..
2. "Grade" tunnel, horseshoe 11′ 0″ high x 10′ 9″ wide	0.3	2.5	..

(C) Kensico Reservoir, Upper Effluent Gate-chamber to Filter Connection Chamber.

1. Reinforced concrete aque., 17′ 0″ diam. containing 1 Venturi meter with 7′ 9″ throat, 40′ max. head*	0.43	..	..
2. Reinforced horseshoe aque., 17′ 0″ high x 13′ 4″ wide, max. head*	0.07	..	..
3. "Grade" tunnel, horseshoe, 17′ 0″ x 13′ 4″ wide	1.5	..	..
4. Riveted steel pipe, concrete-covered and mortar-lined, steel shell 9′ 9″ diam.	0.31	2.3	..

(D) Filter Connection Chamber to Influent Gate-chamber at Hillview Reservoir.

1. Plain concrete horseshoe "cut and cover" aque. 17′ 6″ high x 8′ 0″ wide	7.4	..	..
2. "Grade" tunnel horseshoe 17′ 6″ high x 13′ 9″ wide	0.63	..	..
3. "Pressure" tunnel, 16′ 7″ diam.	2.53	..	..
4. Riveted steel pipe concrete-covered and mortar-lined; steel shell 11′ 3″ diam.	1.58	..	..
5. Reinforced concrete siphon, 16′ 7″ diam., 12′ max. head*	0.03	12.2	..
Total length of Aq., Ashokan Res. to Hillview Res.			91.6
(E) Hillview Reservoir. By-pass = 12′ 0″ diam. void in concrete dividing wall		0.5	0.5

II. City Aqueduct.

(A) Hillview Reservoir to City Line.

"Pressure" tunnel, 15′ 0″ diam.		0.4	..

(B) City Line to Brooklyn Distributing Center.

1. Pressure tunnel 15′ 0″ diam.	7.37	..	..
2. " " 14′ 0″ "	4.96	..	..
3. " " 13′ 0″ "	0.86	..	..
4. " " 12′ 0″ "	1.71	..	..
5. " " 11′ 0″ "	2.52	17.4	..
(C) Spur "Pressure Tunnel" line to Ft. Greene Park; 11′ 0″ diam.	..	0.3	..

(D) Spur line to Richmond (Staten Island) via Brooklyn and The Narrows.

1. 66″ steel pipe in Brooklyn	3.23	..	..
2. 48″ cast-iron pipe in Brooklyn	3.10	..	..
3. 36″ submerged flexible-jointed cast-iron pipe across The Narrows (ultimately two lines like this)	1.86	..	..
4. 48″ cast-iron pipe in Richmond, from Narrows to Silver Lake Reservoir	1.78	10.0	..

* Maximum head measured to intrados of arch at crown.

(*E*) *Spur Line to Queens.*	Miles	Miles	Miles
1. 66″ steel pipe	2.36	..	..
2. 48″ cast-iron pipe	3.95	6.3	..
Total length of City Aqueduct			34.4
Total length of all main aqueduct			126.5

Summary of Aqueduct by Types.

	Miles
Plain concrete "cut and cover" aqueduct	51.0
Reinforced concrete aqueduct including 3 Venturi meters	2.9
Grade tunnel	13.6
Pressure tunnel	35.5
Concrete-covered mortar-lined steel pipe	6.2
Plain steel pipe	5.6
Hub and spigot cast-iron pipe	8.8
Flexible joint, cast-iron pipe	1.9
Miscellaneous	1.0
	126.5

Figs. 7 and 8 show cross-sections of the most important types of aqueduct in their simplest forms, *i. e.*, in loose earth without rock in

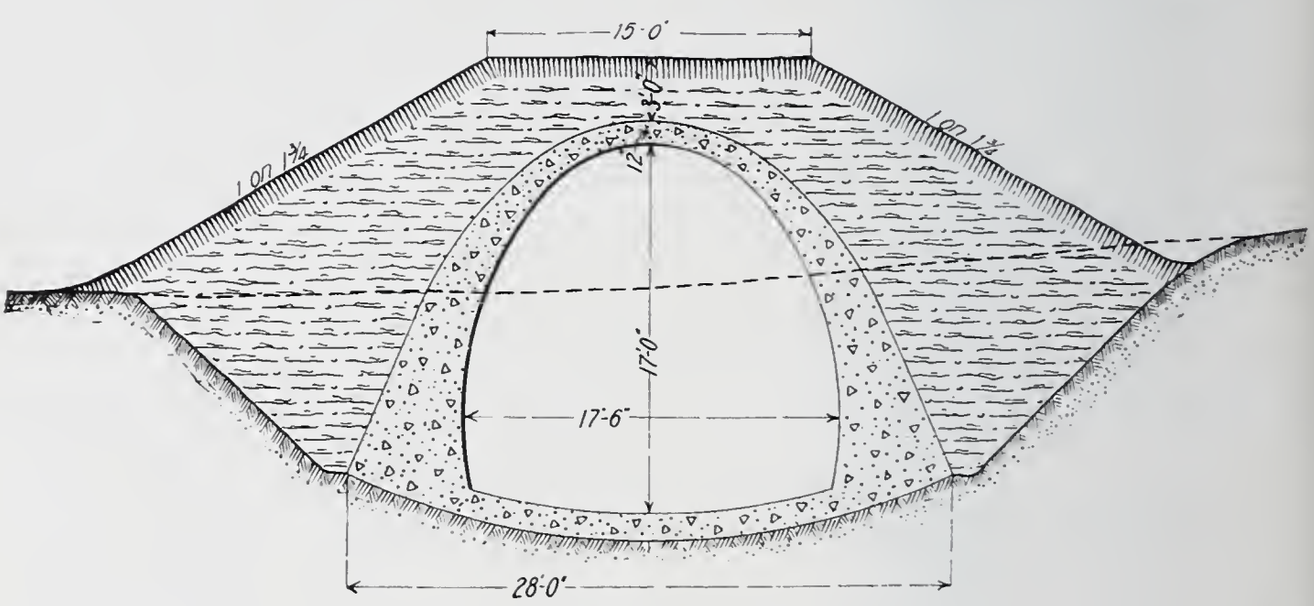


Fig. 7.—Cut and cover aqueduct.

the case of the types in open cut, and in sound rock which does not require permanent timber or steel support in the case of the tunnels. The country traversed by the aqueduct is a rugged one, and this effect is magnified by the condition that for much of its length the aqueduct traverses in a southerly or southeasterly direction a country wherein the ridges and valleys run in a northeasterly and southwesterly direction. South of Hillview reservoir land is all so low as to preclude any but types of aqueduct that can withstand head.

"Cut-and-cover" Aqueduct.—The horseshoe-shaped aqueduct of plain concrete, built in open cut or on embankment, called for brevity "cut-and-cover" aqueduct, is by far the cheapest type; hence economic comparison of the many routes studied necessarily resulted in choice of locations having a maximum of the cut-and-cover type. As indicated in the table, pages 198 to 200, more than half of the aqueduct north of the city is of this type.

The invert is generally 16 inches thick and of sufficiently large radius in cross-section to permit screeding with moist concrete, *i. e.*, the slope at side walls is about 1 on 2½. The arch is of a basket-handle shape that follows closely the line of arch pressure obtained with assumptions of about one-third for ratio of horizontal to vertical earth loads. The arch is generally 12 inches thick at crown.

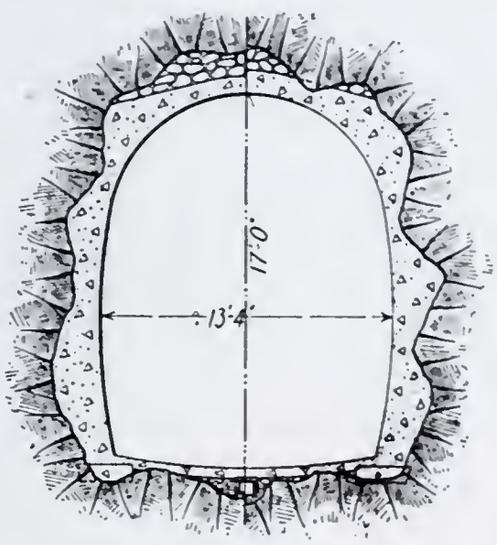


Fig. 8.—Grade tunnel.

Fig. 9 shows the steps in construction. The invert is screeded in length of 15 feet, and beneath the transverse joints, to intercept leakage, are blocks* of concrete 16 inches wide with smoothed tops. In rock cut, and in earth compact enough to take the thrust of the arch, the concrete is laid directly against the bank, thus omitting the toe of the side wall. In loose earth the side wall and arch are laid monolithic.

Transverse joints in side wall and arch occur at intervals from 15 to 75 feet, generally about 45 feet. Two types of transverse joint are still in competition,* viz., one with a steel plate embedded across

* Note, March 17, 1911: A decision has recently been reached, based on tests to date, to use steel plate 6″ x ⅜″ in side wall, arch, and invert during the coming year.

Fig. 9.—Cut and cover aqueduct 17′ 0″ high by 17′ 6″ wide. Steps in construction.

the joint, and the other made by carefully formed dovetailing of the concrete, especial attention being paid to smoothness of surface and "draw" to prevent keys from pulling apart instead of slipping.

A cut-and-cover aqueduct of such large size presents many complex problems as to accuracy, strength, and convenience of forms and handling of excavation and concrete. Those contractors who expected to evolve successful forms or methods out of their inner consciousness, without experimentation, were all disappointed so far as the writer knows, but sufficiently heavy and accurate forms and successful methods have now been developed.

Grade Tunnel.—Where one of the many divides is to be passed, or where following around a promontory makes a relatively great increase in length of cut-and-cover aqueduct, there is used a tunnel at the hydraulic gradient, called for brevity "grade" tunnel. There are twenty-four such tunnels, aggregating 13.6 miles, in the aqueduct from Ashokan reservoir to Hillview reservoir. The grade tunnel is of less waterway area than the cut-and-cover aqueduct, because there was some saving in making the more expensive types of construction of less size. It is made of the same height as the cut-and-cover aqueduct because possible air-trapping troubles could thus be avoided, and the high and relatively narrow tunnel was found probably to be as cheap per cubic yard as one of which height and width are more nearly equal.

For the crossing of the many valleys between Ashokan reservoir and Hillview reservoir, three types of construction are used, viz., "pressure" tunnel, steel pipe, and reinforced concrete aqueduct, each according to conditions.

Pressure Tunnels.—The Catskill aqueduct is unique in the number, length, and depth of the tunnels in rock which are to be used to carry high unbalanced internal water pressures. In the whole aqueduct north of Hillview there are seven * of these so-called "pressure" tunnels, aggregating about 17.4 miles, reached by shafts seldom less than 350 feet, and, in the case of the Hudson river crossing, 1150 feet, in depth. With the aqueduct in service, these tunnels carry unbalanced internal heads generally 200 feet or more, and in the case of the Hudson crossing, 410 feet. Much of the city aqueduct also is pressure tunnel; this is referred to later in the paper.

* Three of these, while named separately, are adjoining, and really form one long siphon.

The pressure tunnels have many important details, but will only be touched on here, as they have been very fully described by the writer in another paper,* which has been generally quoted from in the technical press. Figs. 10 and 11 show the essential features of several of the pressure tunnels. Note the end shafts, called respectively the "downtake" and the "uptake" shaft, at which are chambers connected with the aqueduct at the hydraulic gradient, and containing screen racks or barriers, stop plank grooves, crane, etc. Note also the drainage shaft and chamber, at which are provisions for an unwatering plant consisting of electric multi-stage centrifugal pumps carried on a float which sinks as the water is lowered. The discharge pipe is built up as the float sinks.

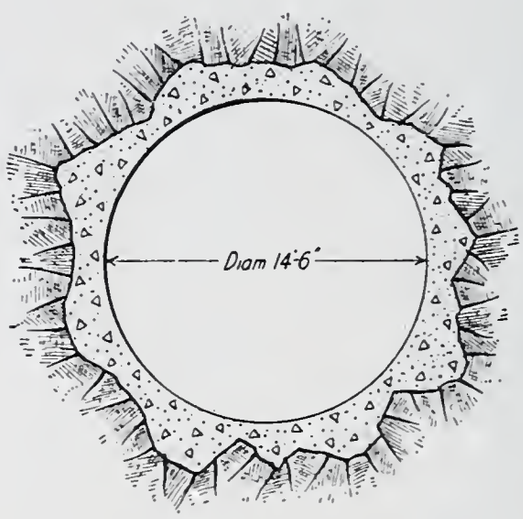


Fig. 10.—Pressure tunnel.

The pressure tunnels are placed at such an elevation, determined by frequent core borings, that sound rock to a depth of at least 150 feet will exist above them. All voids around the concrete lining and fissures in the rock will be filled as thoroughly as possible with grout forced in under pressures exceeding the resisting ground-water head. Short stretches of special metal lining will be used if unsatisfactory rock is met.

Hudson River Crossing.—Much newspaper comment has been directed at the Hudson River crossing, probably because drilling explorations were visible from the trains and river steamboats. Much futile labor has been expended in trying to find depth to rock

* See paper entitled "The Design of Pressure Tunnels of the Catskill Aqueduct," in Proceedings of Municipal Engineers of the City of New York, 1909.

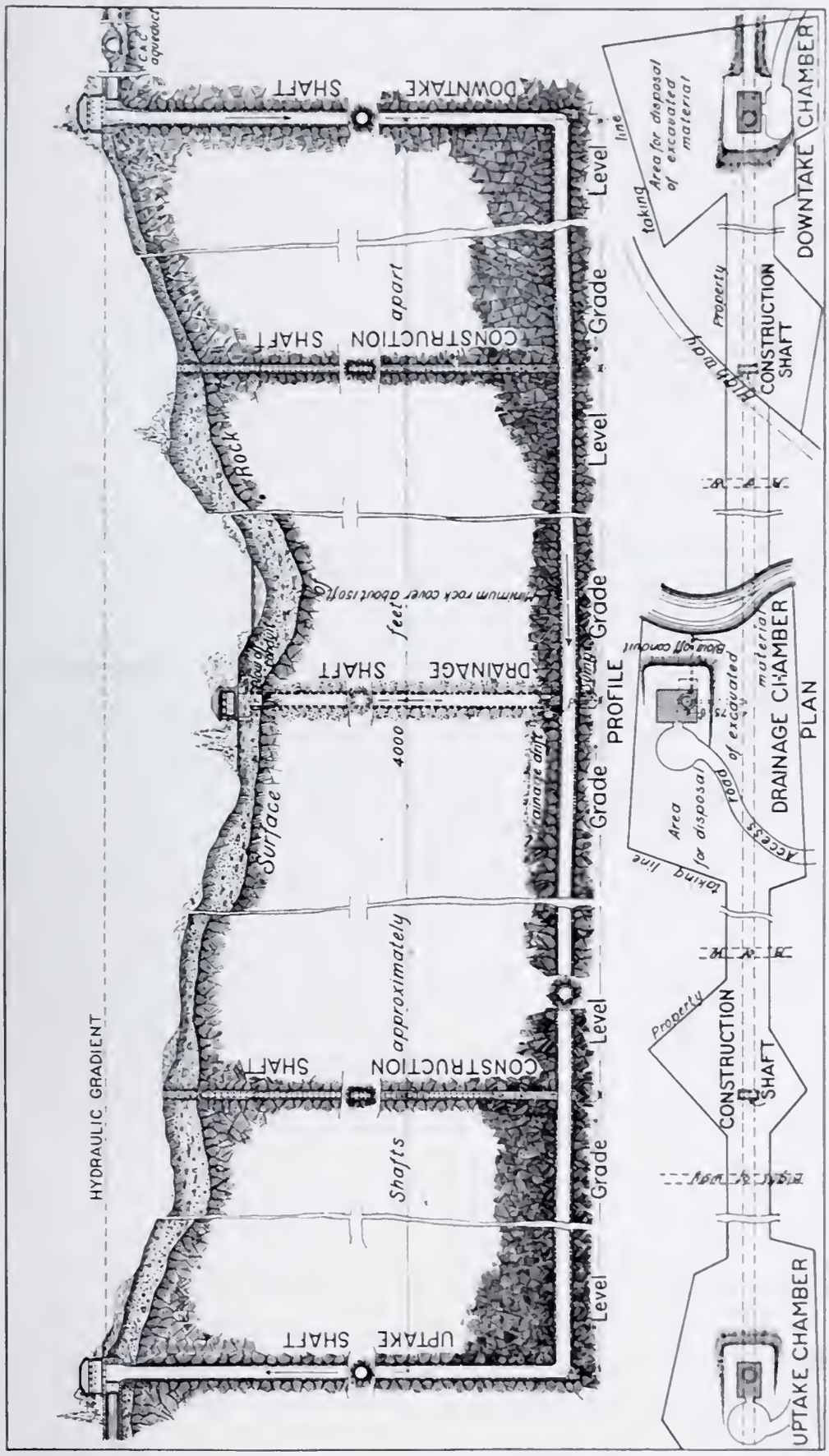


FIG. 11.—Typical pressure tunnel.

in mid-river by borings from scows. A depth of 766 feet was reached, but rock not encountered. The engineers always felt pretty certain of good rock not much deeper, as the proposed crossing was between the highest of the granite hills, viz., at Storm King, a little north of West Point; and the rock was found by two pairs of sloping diamond drill borings which were drilled beneath the river from chambers located about 200 feet below river level in shafts sunk one on each

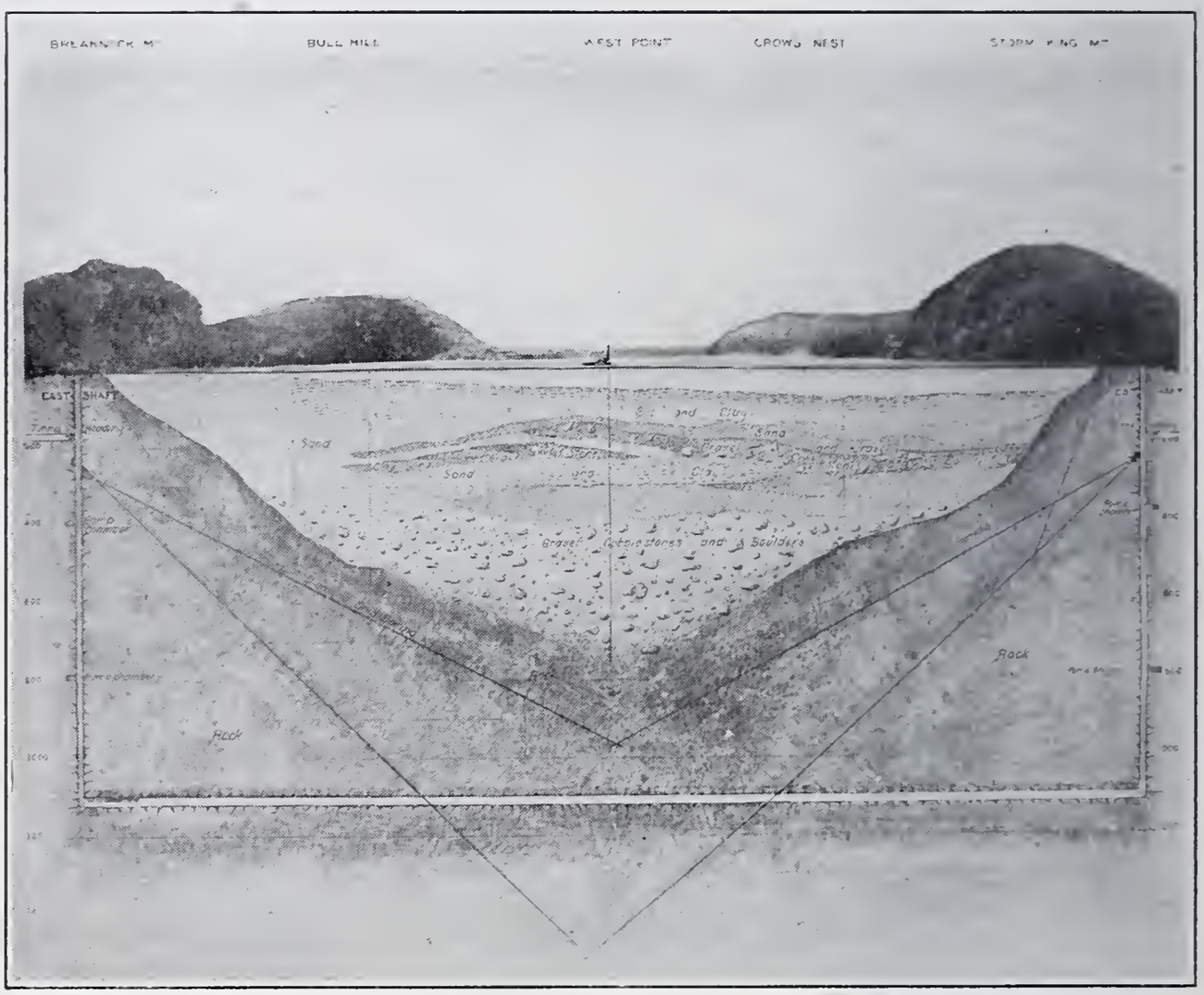


Fig. 12.—Hudson river crossing.

bank. These borings remained wholly in solid rock. Borings of one pair passed each other at approximately elevation –960, and borings of the other pair passed each at approximately elevation –1500. The tunnel is now being driven at about –1100. Fig. 12 shows a cross-section of the river with borings plotted.

Steel Pipe Siphons.—In several of the deeper valleys, which it was at first hoped would be crossed by pressure tunnel, rock was found

of too doubtful quality; or so deep in proportion to the width of valley as to make the cost of the pressure tunnel prohibitive, due to a very large proportion of vertical shaft. For these, steel pipe was adopted, as also for certain lesser valleys, for reasons described further on, under "Reinforced Concrete Aqueduct."

The steel pipe siphons north of Hillview reservoir are fourteen in number and aggregate 6.2 miles. Each siphon will ultimately have three lines of pipe, two of which are deferred for the present. At the end of each steel pipe siphon is a housed-over chamber providing an easy junction between the single-grade aqueduct and the three pipe lines, and containing a bronze-mounted cast-iron sluice-gate and stop-plank grooves at the head of each pipe.

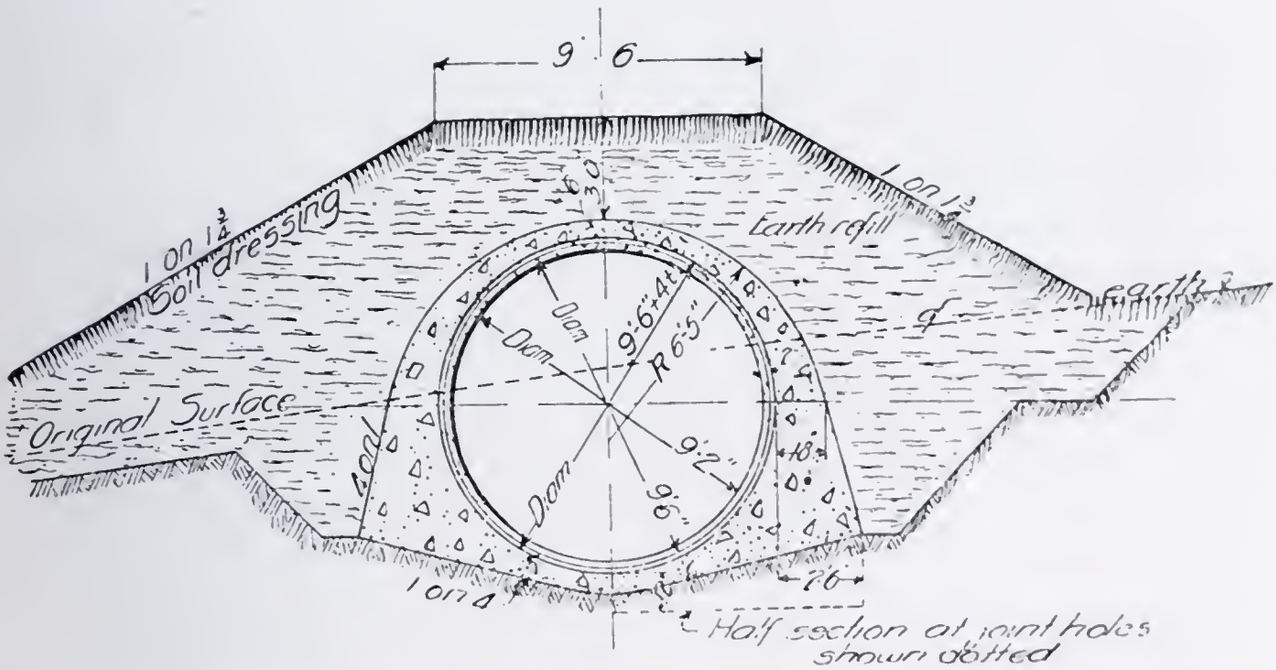


Fig. 13.—Concrete-covered mortar-lined steel pipe. Steel shell 9′ 6″ diameter.

The construction (Fig. 13) is unique in that the steel pipes are both surrounded by an "aqueduct section" of concrete and lined with mortar, having a uniform diameter 4 inches less than the inner courses of the steel plate. This style of construction was actually found cheaper than plain steel pipe because the higher coefficient* of flow enabled three pipes of shipable size to do the work of four equal-sized unlined pipes; also a longer life† could be properly assumed. The specified method of lining, viz., by pouring 1 : 2

* Assumed 125 in Chezy formula, as against 85 for plain steel pipes.

† Seventy-five years *vs.* thirty-five for plain steel pipe.

mortar around a form was successfully tested with a piece of pipe 9 feet in diameter, together with other methods, before the type was adopted.

Reinforced Concrete Aqueduct.—At the outset economy was looked for in the use of reinforced concrete pipes for the siphons crossing depressions having a depth of less than about 125 feet below the hydraulic gradient. A test was made of a reinforced concrete pipe 11 feet in diameter and 210 feet long, built of 1 : 2 : 3½ concrete 8 inches thick except at lower parts of side wall, and reinforced with welded rods of an area such as to be stressed 10,000 pounds per square inch with a head of 125 feet on the pipe. This pipe was very perfectly constructed, and after a few repairs of leaks found in preliminary tests, was satisfactory for about two-thirds the 125-foot head; also fairly satisfactory from a commercial standpoint for the 125 feet. But opinion was unanimous that, for so important a work, 50 feet head, with steel enough to limit the stress to 6700 pounds per square inch, was as far as it was proper to go.

Three short siphons and three depressions in grade aqueduct to contain Venturi meters are of reinforced concrete; also 2 miles of 11-foot diameter Kensico by-pass, which is under a head varying from 5 to 35 feet, and about 2000 feet of 17-foot diameter aqueduct between Kensico Reservoir and the filter connection chamber, which with filters in service is under a head varying from 10 to 40 feet measured above the crown of arch. This aqueduct was laid low so as to enable 10 feet more to be drained out of Kensico reservoir by by-passing the filter plant and eliminating the 10 feet loss of head reserved for it. All this reinforced aqueduct is even much more, probably 100 per cent. more, conservatively designed than called for by the limits of 6700 pounds per square inch stated above.

Full Capacity Blow-offs.—At three points on the aqueduct, viz., Wallkill and Hudson Rivers and Croton Lake, are blow-offs capable of discharging the whole capacity of the aqueduct, and so set in shafts or depressions as actually to intercept the whole flow and prevent it from running to a break conceived as occurring further down-stream. Valves are hydraulic and arranged to operate by the water in the aqueduct. Duplicate gates are put in line so that they may be tested one at a time without wasting water. Gates at the Hudson blow-off are under 400 feet head and a velocity of 120 feet per second is required. Many smaller blow-offs are, of course, provided at avail-

able streams, including one of 250,000,000 gallons daily capacity a few miles north of Hillview reservoir.

Gaging Manholes, Venturi Meters, Boat Holes.—Five gaging manholes, arranged for current-meters, are provided at intervals along the aqueduct. A Venturi meter is placed in the aqueduct near Ashokan reservoir, another a little north of Kensico reservoir, and a third a little south of Kensico reservoir. A bronze casting about 1 foot long containing the up-stream pressure chamber, and a bronze casting about 7½ feet long at the throat, also containing the pressure chamber, are the only part of the meter tube not constructed of reinforced concrete. The tube and the throat diameter in two meters are 17.5 and 7.75 feet respectively, and in the third 17.0 and 7.75 feet.

A covered opening, usually 4.5 by 17.5 feet, to permit putting in and taking out a boat, is provided at each end of nearly every stretch of grade aqueduct.

Slopes and Hydraulic Gradient.—The controlling elevations of the hydraulic gradient and general slopes of various types of aqueduct are as follows:

NORTHERLY SECTION OF AQUEDUCT.

Elev. of lowest fall draft from Ashokan reservoir, approx.	511
Elev. of ordinary high water in Kensico reservoir	355
Cut-and-cover aqueduct 17′ high x 17′ 6″ wide, slope *	= .00021
Grade tunnel, 17′ high x 13′ 4″ wide, slope *	= .00037
Pressure tunnel, 14′ 6″ diameter, slope	= .000615
Pressure tunnel, 14′ 2″ diameter, slope	= .000687
Pressure tunnel, 14′ 0″ diameter, slope	= .000729
Steel pipe, 9′ 2″ inside lining, slope	= .00067
Steel pipe, 9′ 5″ inside lining, slope	= .00059

KENSICO RESERVOIR TO FILTERS.

Elev. lowest full draft from Kensico reservoir, approx.	337
Elev. of water on filters	322

Aqueduct 17′ circular and 17 x 13′ 4″, all under head.
Slopes all special, as is also case for aqueduct just south of Ashokan reservoir, to allow for extra fouling near intakes.

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* These grade aqueducts are built to the slopes. For siphons the slope is in hydraulic gradient, and is used in addition to special losses at siphon chambers, etc., to fix total drop between siphon chambers. Following are some of special losses assumed: 90° curves $.15\frac{V^2}{2g}$, tee-shaped junctions $.33\frac{V^2}{2g}$, siphon chambers, .25 foot. Headworks losses are more considerable, but too numerous to list.

FILTERS TO HILLVIEW RESERVOIR.

Elev. of water in effluent from filters	312
Elev. of high water in Hillview reservoir	295
Cut-and-cover aqueduct, 17′ 6″ high x 18′ 0″ wide, slope*	= .000182
Grade tunnel, 17′ 6″ high x 13′ 9″ wide, slope*	= .00032
Pressure tunnel, 16′ 7″ diameter, slope	= .000313
Steel pipe, 10′ 9″ inside lining, slope	= .000281

The relative sizes of various types in each stretch were fixed by economic determinations, explained at length in the writer's paper referred to on page 204.

City Aqueduct.

Pressure Tunnels.—From Hillview reservoir to Brooklyn, also for a short spur in Brooklyn, 18.1 miles in all, the City aqueduct is a pressure tunnel, stepping down in size, 15, 14, 13, 12, and 11 feet in diameter. The tunnel is reached by twenty-five shafts, generally between 180 and 300 feet deep, but over 400 feet at the Harlem River and the buried gorge just southerly, and over 700 feet at the buried gorge in Manhattan near the East River.

The northerly shaft is in the effluent gatehouse of Hillview reservoir and serves as downtake. The other twenty-four shafts are numbered from 1 to 24, beginning at the north. Shaft 1 has no connection to the distribution system and is to be completely plugged. Shaft 11 is designed and equipped solely as an unwatering shaft. All the other shafts have one or two risers, 48 or 72 inches in diameter, for connection to the distribution system. Shafts 13 and 18 have also bronze "section valves," 66 inches in diameter, which can be used to shut-off or throttle the flow in the tunnel. Just north of shaft 2, in the tunnel, is a Venturi meter with bronze throat and bronze up-stream chamber substantially as described for meters in open cut aqueduct. (See p. 209.)

The risers and appurtenances for connecting the tunnel with the distribution mains warrant a brief description. (See Fig. 14.) The concrete plug closing a shaft is to begin at least 100 feet down in sound rock. In this plug is embedded one or two steel pipe risers, and these are lined with concrete about 5 inches thick. At the lower end of each riser is a valve consisting of a bronze seat casting and a bronze pear-shaped plug which is raised or lowered by lever operated by a rod running from the "dry" side of the valve to the surface. This plug shuts with the pressure and is held open by its weight and

* See foot-note on page 209.

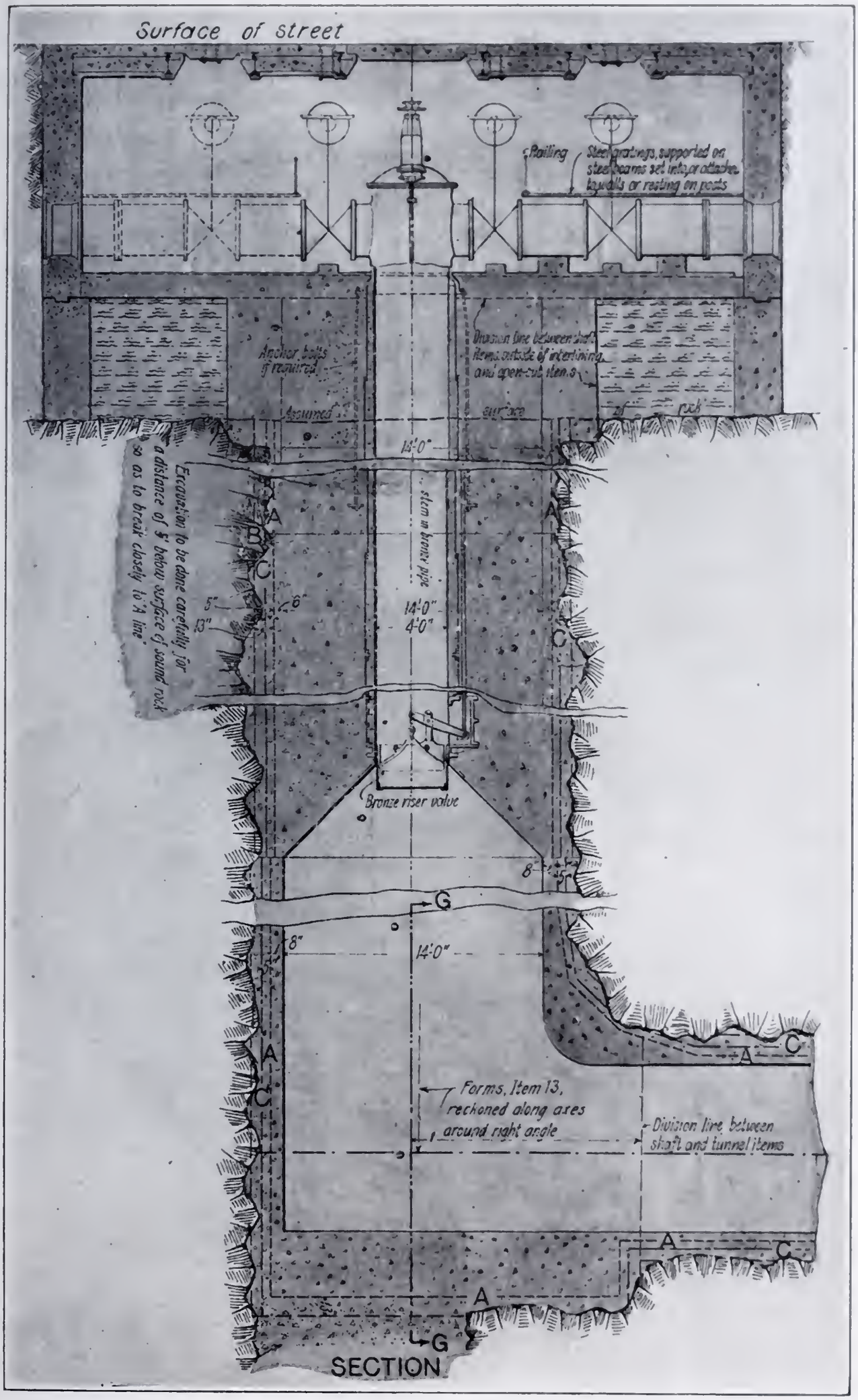

Fig. 14.—Typical shaft of city tunnel.

by tension of the rod. The rod is hung at top so as to be releasable by operating a magneto set at some distance in a post somewhat like a fire-alarm box. A dash-pot governs the closing. This valve is an emergency valve and does not need to be tight.

The riser terminates in a bronze cross. The top opening of this cross has a cover and is used as an access. The side outlets have each a bronze valve for stopping the flow wholly and not to be worn out by use in throttling. Near each bronze valve is a bronze-mounted cast-iron valve for throttling.

Pipe Lines.—The pressure tunnel in Manhattan does the work of at least a dozen 60- or 66-inch mains, saves street room needed for subways and other pipes, and is much cheaper than the pipe lines would be. In Brooklyn, Queens, and Richmond the rock is too deep for tunnels, even if they would be economical for these smaller spur lines. Steel pipes, generally 66 inches in diameter, the largest that can be put in streets without relaying all the sewer connections, are used for the beginnings of these spur lines and cast-iron pipes 48 inches in diameter for smaller extensions.

Narrows Siphon—36-inch Flexible-Joint Pipe.—An interesting and important undertaking is the laying of nearly two miles of 36-inch ball-and-socket pipe across the Narrows to Richmond (Staten Island). The water is deep, reaching a maximum of 60 feet, the current strong, and wind, fog, and traffic combine to enhance the care required.

In conclusion the writer wishes to make acknowledgment of the assistance given by his colleagues, Fred F. Moore and Chas. E. Gregory, designing engineers, in furnishing detailed information relative to the portions of the work under their charge.

DISCUSSION.

Carl P. Birkinbine.—You stated that you had taken very careful means to drill holes straight under the Hudson River. Why should you suppose they could not be drilled straight?

Mr. Wiggin.—The general experience is that holes do not go straight, especially those that are not vertical. I investigated many such holes drilled in the Great Lakes mining region, where for some years it has been the general practice to measure the dip of each hole about every 50 feet, and to start the holes on a slope so as to determine the orientation. Most holes will become more nearly horizontal as they progress, due, it is thought, to the sag of the rod, except at the bit. The amount of clearance of the core barrel in the holes, difference in pressure and in speed of drilling, and variations of hardness of rock each have an

effect more or less well known. A large drill, small clearance of core barrel and of two or three following sections of rod (obtained by close setting of diamonds and frequent removal of core barrels and rods), and comparatively light pressures and high speeds are the usual precautions taken in drilling straight holes.

The first pair of holes under the Hudson River were purposely directed low, with the idea that they would curve upward; at the same time unusual precautions were taken to keep them as straight as possible, including the use of a very large hole—namely, 2¾ inches in diameter. These precautions were so successful that the holes were nearly straight, and it was found impossible to bend them up to the elevation required, though some upward curve was obtained by reducing the size of drill, first to about 2 inches and then to about 1⅜ inches. The second pair of holes was directed on the assumption that they would be straight, which proved to be the case, no effort being made to bend them.

To test the direction of a hole, only one of the several devices invented is very satisfactory; that is a glass bottle with a solution of hydrofluoric acid, which will etch a horizon on the bottle. Frequently two or three bottles are used simultaneously in a test and the results averaged. Owing to capillary attraction, the horizon is not etched in a true horizontal plane, and an empirical scale has to be determined by setting the tube at known angles and comparing corresponding angles measured from the horizon etched on the glass.

Only that portion of the drill rod which is near the drill is the same size as the hole drilled. The core barrel wears out very quickly and has to be watched. I have record of one hole entering the rock at a dip of 12 degrees and actually coming out of the ground in a length of 900 feet at a point 128 feet higher than the starting-point. Another hole 820 feet long changed its dip from 70 degrees at the start to 8 degrees. Many other records are available of holes changing nearly as much as this in direction.

Dr. H. M. Chance.—What was the final deflection from the original angle in the case of the Hudson River borings?

Mr. Wiggin.—The upper pair of holes started with a dip of a little more than 40 degrees. The one from the west shaft was about 2½ degrees steeper at mid-length, 3 degrees flatter at three-quarter length, ended about 2 degrees flatter and averaged about 1 degree flatter than at the beginning. The one from the east shaft was about 1 degree steeper at 500 feet, 5 degrees flatter at 1400 feet, ended about 4½ degrees flatter, and averaged nearly 2 degrees flatter than at the beginning. The upper or second pair of holes started at somewhat more than 23 degrees dip. Neither of them varied over 2 degrees from the original direction and both ended within 1 degree. These results are from a careful plotting of the deflection records rather than the records themselves. Individual readings probably show greater variation.

Dr. Chance.—How do you know that the hole does not reflect laterally?

Mr. Wiggin.—There were no means of determining the lateral deflection except by the way the bit acted. It seems, however, almost a certain inference in this case that the hole was at least as straight in a lateral plane as in a vertical plane, since the vertical plane has the main factor which produces deflection. In any case it would require considerable lateral deflection to greatly impair the value of the information.

I think, without exception, the Rondout siphon is the most difficult work

so far encountered. The Hudson River crossing is more spectacular, but there has never been much doubt in the engineers' minds of finding good conditions at some reasonable depth, and mere depth is not an important difficulty. The rock at the Hudson crossing is a beautiful rock, solid granite (granitic gneiss), with no important weaknesses. There is good reason to hope that the rock will continue reasonably dry. The Rondout siphon comes through a very mixed country, geologically speaking. Some of the rock is faulty and very wet and will require careful treatment to prevent leakage, possibly steel interlining. Several caves in the rock, filled with clay-like material, were encountered.

Paper No. 1099.

A REVIEW OF THE PROGRESS OF CITY PLANNING.

B. ANTRIM HALDEMAN.
(Active Member.)

Read March 18, 1911.

The "city plan," as generally understood, deals chiefly with the street system, but in a broader sense it also includes, or should include, the distribution of parks, squares, playgrounds, and other open public places, the improvement of the water-fronts and all other public property which may be entirely subject to municipal control. The "city plan" is the foundation and framework upon which the city is built, and its character affects, directly or indirectly, every department of the city government, every class of society, and every branch of industry and trade. But modern "city planning" goes much farther than this and has a far broader scope; it goes beyond streets and squares and involves every function of the city; it reaches the homes and the health, the work and the play, of the community; it aims toward the systematic co-ordination and development of the physical features and the social forces of the city in a manner which shall give greater encouragement and larger opportunity for every legitimate enterprise and ambition of its people; it is altruistic in its intent, and its ultimate object is the making of better citizens as well as better cities; in its most comprehensive meaning and its broadest intent it involves so many and such varied physical and social elements that no one person can hope to solve, or to suggest solutions for, all of its problems. The planning of a modern city which shall fully satisfy all present needs and anticipate and meet the necessities of the future in any large degree demands the best service of the skill and genius of many professions, arts, and trades, no one of which, working alone, can accomplish great results, but all of which, working in co-operation, may achieve a large measure of success. Its social and economic problems do not directly concern the engineer, but his skill and wisdom are essential to the creation and intelligent development of those large constructive enterprises necessary to municipal progress and to the health, comfort, conve-

nience, and safety of the masses of humanity which we find congregating in modern cities.

Formal city planning seems to have been in vogue at least five thousand years ago. Kahun, a city built to accommodate the workmen and others engaged in erecting the Pyramid of Illahun, about 3000 years B. C., had a regular and rectangular system of streets, and this seems to have been characteristic of all those ancient Egyptian cities whose stupendous ruins have aroused the wonder of the world. The cities built by the conquerors of the Egyptians had

Fig. 1.—Plan of ancient Alexandria, 323 B. C.

regular street systems, as is illustrated in the plan of ancient Alexandria, laid out by the architect of Alexander the Great, 323 years B. C.

The Greeks and Romans, in the zenith of their classic glories, erected the noblest cities the world has ever seen. They were masters in the arts of engineering and architecture, and the masterpieces of their skill have descended through the centuries, the admiration and despair of every succeeding generation of their fellow-craftsmen. Although their capitals, Athens and Rome, grew irregularly and without definite plan, the other cities which they founded were laid

out regularly and rectangularly. In Rome we find the first great example of the replanning of a city upon a large scale. The Emperor Nero wearied of the rambling and chaotic conditions of the imperial city and was ambitious to undertake vast improvements; this he was unable to do by reason of the violent opposition of property owners and of the powerful priesthood, many of whose temples, shrines, and altars, which were innumerable and were esteemed sacred and inviolable, would have to be destroyed. To accomplish his purpose the emperor directed his architects to prepare elaborate plans for rebuilding the city and for housing and caring for the people whom the violent scheme he contemplated would make homeless for a time; then he applied the torch and began the horrible butchery of the Christians to distract the attention of the people and protect himself and his court from a fury which would otherwise have been directed against them. His device, extreme and awful though it was, succeeded, and Rome was recreated on a scale of great magnificence.

The evil days which fell successively upon Egypt, Greece, and Rome saw a violent decline in the arts of city building. Their splendid cities fell into decay with the nations which had created them, and those which rose upon their ruins reproduced but little of the grandeur and dignity of their stately predecessors.

During the Middle Ages, when the world was a battle-ground and only the law of the survival of the fittest prevailed, formal city building found no place in the activities of the feudal chiefs, who dwelt with their retainers in strong castles or walled cities which permitted but narrow opportunities for progressive or permanent development.

During the succeeding period, when the identity of nations was being established and their political boundaries were being formed, the perpetuation of the monarchical régimes which seized and held the reins of governmental power depended upon the control of masses of people, and there was a strong movement toward congregation in cities. But even during this period the recovery of the higher arts of civilization was very slow, and there was little improvement in the methods of city building except in the cases of towns laid out by kings and princes for royal residences or pleasure places.

The intense activity in the work of exploration, conquest, and colonization during the seventeenth century greatly increased the wealth of western Europe by opening new fields for industry and trade, and city building received a new and strong impulse. The arts of war

began to give way to the arts of peace; the ancient fortifications and medieval streets which had seen service for centuries had no place in the new era of world-progress and began to disappear; industrialism gradually advanced to a position of such importance that radical changes in city building became necessary in order to maintain positions of prestige and influence in the new international competition for commercial and political world-power, and the middle of the nineteenth century found the cities of western Europe industriously engaged in the work of demolition and reconstruction.

Paris was the first of the capitals of the old world to feel the compelling influence of the new order of things and the first to throw off the fetters of the old feudalism. Paris offers the most conspicuous example of what may be accomplished in the rebuilding of cities, for the Paris of today is not, in its street system or architectural features, the Paris of a century, or even half a century, ago. But the conditions under which the transformation of Paris into the most magnificent city of modern times was accomplished were exceptional; the engineers and architects who directed the work had behind them the authority of autocratic power, and were as powerful in matters relating to the public work they were commissioned to perform as their sovereigns were in the affairs of government. The beautiful Paris of today is the result of a long process of intelligent and systematic rebuilding which had its first strong impulse four hundred years ago, during the reign of Francis I, who was a great builder and who began the Louvre, erected many churches and other fine buildings, and made considerable progress in improving and beautifying the city. Louis XIV undertook the work of embellishment on a grand scale; he removed the old fortifications and created in their place the present grand boulevards, extending in a great, irregular line from the Madeleine to the Place de la Bastille, and laid out the avenue of the Champs Elysees and many other fine avenues and public squares. Then for a period of nearly a hundred years progress was slow and spasmodic, until Napoleon I, bringing home the rich plunder of his victorious campaigns, took up the work and prosecuted it with great vigor; he opened many new avenues and squares, built new bridges, and extended the quays and embankments of the Seine. Later, Louis Philippe spent over twenty million dollars in similar improvements.

But it remained for Georges Eugene Haussmann, acting under plenary power conferred upon him as Prefect of the Seine by Napoleon

Fig. 2.—Plan of Paris at the close of the Second Empire, 1872.

III, between 1852 and 1870, to take up the improvements commenced during the preceding two centuries, and by practically replanning and rebuilding the city assemble them into the present comprehensive and magnificent combination of broad avenues, great squares, imposing monuments, and beautiful buildings. Napoleon III had no sentimental interest in art or beauty, but he wanted wide, straight avenues in which he could more easily control his turbulent people, and through which his victorious legions might lead royal prisoners returning from the campaigns he planned and dreamed would place

Fig. 3.—Place de la Concorde, Paris.

his own name as a statesman and conquering captain higher upon the scroll of fame than that of his illustrious kinsman.

Haussmann was as fortunate as he was wise and far-sighted in the administration of his great task. He was fortunate in having behind him the power and patronage of the most autocratic and ambitious monarch of Europe, who cared nothing for the cost so long as it promised to advance his personal aims and ambitions; he was wise in his understanding of human nature and the temper of the people, and in his knowledge of the influence of art and beauty to attract culture, wealth, and power, and he had the unerring prevision that

in the industrial struggle of the coming years only those cities would be reckoned really great which gained and held the favor of the cultured, the wealthy, and the powerful. Napoleon's ambitions were forever crushed at Sedan, but Haussmann's art still lives in the fame and beauty of the French capital, and marks him as the greatest city-builder of his century; his skill and wisdom have made his city the focal point of interest of all the world, and the two hundred and sixty-five million dollars spent in his work has been repaid manifold. But Paris does not rest upon past achievement, and its visitors today will find broad, new avenues being opened through solidly

Fig. 4.—Alexander III Bridge, Paris.

built-up blocks in many sections of the city; almost within a year one hundred and eighty million dollars have been appropriated for the further improvement of Paris, and the experience of that city is perhaps the most practical argument that can be put forth that art and usefulness, beauty and serviceability, can and should go hand in hand in the work of city planning.

Although the greater part of the work that has left its ineffaceable stamp upon Paris was performed within the span of a little less than two decades, the great lesson taught there is that the rehabilitation of a city is a process that extends through centuries and never ceases. Haussmann made radical changes in some of the costly work of his

predecessors, and the present engineers are opening their new avenues through sections built up during or since Haussmann's time.

London offers a somewhat more practical, but far less brilliant and inspiring, illustration of how to meet the great problem of modern city rebuilding than Paris, for London has been engaged in opening and widening streets through built up areas for half a century. The importance of London as the world's greatest center of population and trade has been steadily increasing since the beginning of the Christian era, but it has grown after the medieval fashion, without any definite plan; its streets are uniformly narrow and rambling, and it is perhaps more in need of systematic replanning than any other large

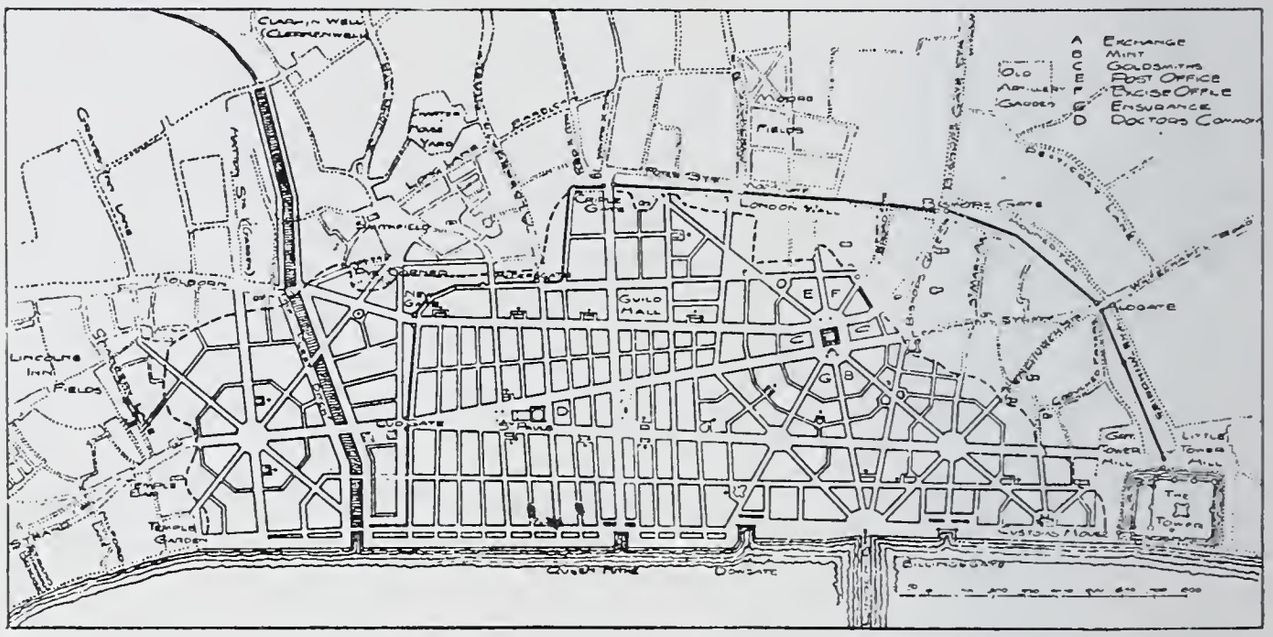

Fig. 5.—Sir Christopher Wren's plan for the rebuilding of London after the fire of 1666.

city of Europe. It is upon the streets of old London that one comes in touch with a congestion of traffic inconceivable and appalling to one who has never traversed the "Strand" or the streets which converge near the Bank of England, and the actual necessity of opening new thoroughfares exists there in the most tangible form.

Had Sir Christopher Wren's plan been adopted in the rebuilding of the city and its principles applied to extensions after the great fire of 1666, inestimable benefits would have accrued and much of the present difficulty and cost of reconstruction would have been avoided; but property rights were sacred, Wren's plan was rejected, and the ancient system, or lack of system, has been perpetuated, with the occasional widening or opening of a new street in the most

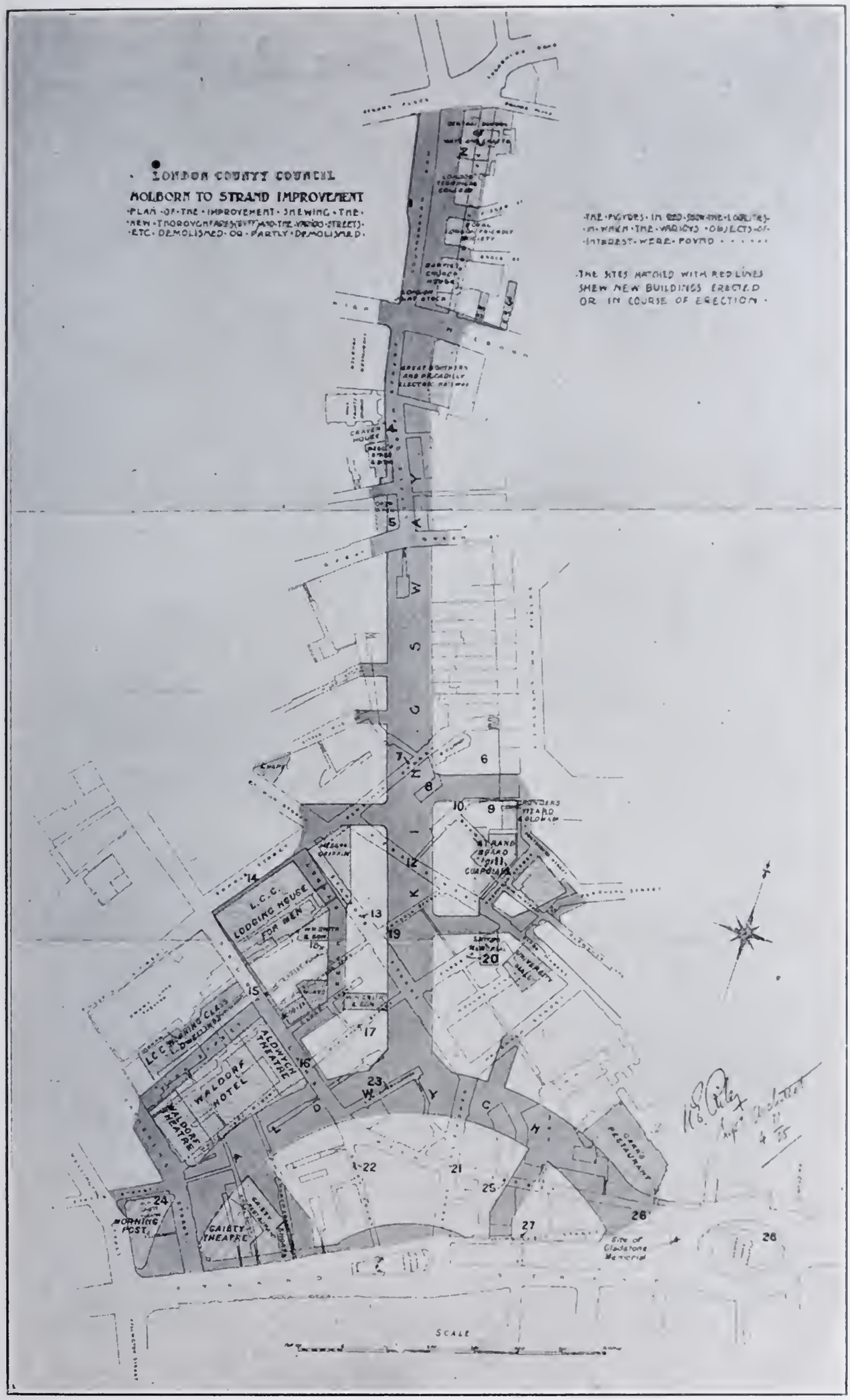

FIG. 6.—Plan of Kingsway and Aldwych, London, opened in 1905.

congested sections. A Royal Commission appointed to investigate and suggest methods for the relief of congestion has recommended the opening of wide streets through all parts of the city. This Commission recommends several classes of streets, ranging from 40 to 140 feet in width, the latter being main traffic streets. One of the most startling statements attributed to the Commission, a statement which all cities might do well to consider, is that "the conditions of life in London and other big towns are such as to produce a degenerate race, morally and physically enfeebled." It may be that this statement is based somewhat upon the report that of eleven thousand men in Manchester who tried to enlist in the army, eight thousand were rejected, two thousand were accepted for the militia, and one thousand were taken for the army. If city life produces, or tends to produce, such conditions, it is high time some of the social problems of modern city planning were solved.

London's latest and most noteworthy achievement, which marks a new departure in methods of procedure in the work of replanning, was the opening in 1905 of Kingsway and Aldwych of the width of 100 feet from High Holborn to The Strand through the very heart of old London; the total length of these two streets is about 3000 feet, and the completion of the entire improvement, including the necessary changes of intersecting streets, was about twenty-six million three hundred thousand dollars. This great improvement had been under consideration in various forms for more than sixty years, but the tremendous cost had prevented its consummation until the London County Council, in 1898, decided to petition Parliament to sanction a plan whereby the Corporation could take control of all property which would be physically affected in carrying the project to completion, and afterward dispose of that portion not actually used. Parliament consented, and the streets were formally opened to travel in October, 1905. The result of the method adopted is that the improvement will ultimately pay for itself without any burden of cost whatever upon the taxpayers. This method of procedure, if sanctioned by law, could readily be employed in American cities in the opening of streets where considerable valuable property must be demolished.

The cities of Germany offer striking examples of the practical and esthetic benefits to be obtained by systematic replanning and rebuilding. After the Confederation of the German States in 1870, the united people set to work earnestly and industriously to build

Fig. 7.—A German street of the nineteenth century.

up the power and develop the resources of the Fatherland; their cities grew like the mushroom cities of the United States. Berlin, for instance, has grown almost as rapidly as Chicago. They soon realized that their cities, most of which were little better than remnants of feudalism, were totally unfitted to meet the necessities of the intensive industrialism which quickly developed; replanning and rebuilding became almost a mania, and in some instances resulted in the destruction of features of great artistic and historic value. Frankfurt-a-Main will serve as a fair illustration of what has happened in

Fig. 8.—A German street of the twentieth century.

all the industrial cities of Germany; here the old fortifications have been leveled and a great park ring or anlage has taken their place, while the city within the walls has been opened in every direction with wide streets. The population of 80,000 in 1871, increased to 335,000 in 1905.

In Vienna is found a most inspiring example of the transformation of an ancient town into a most modern city; there the fortifications, which covered a vast area, remained undisturbed until 1857, when their demolition was ordered, and since that time a model city of the nineteenth century has grown upon their ruins, planned and built

with the most systematic and painstaking care; streets have also been opened and widened through the old town within the walls.

The esthetic and attractive elements have received very much attention in the planning and replanning of European cities, and so thoroughly and successfully have art and usefulness been brought into harmony in all German work that Berlin, Vienna, Budapest, and other cities have become such dangerous competitors of Paris in attracting visitors and trade from every part of the globe that the latter city has found it necessary to undertake vast projects of im-

Fig. 9.—Vienna, Austria; the inner town and fortifications of the eighteenth century.—(From "Town Planning Review.")

provement in order to maintain her prestige. These cities have not only been made better, brighter, and more convenient places in which their people may pursue their business affairs and their pleasures, but their builders have risen to the greatness of a Haussmann in the art of creating those subtle channels through which the world's real money flows steadily into their coffers.

The necessity for remodeling their cities was a warning to European nations to avoid similar difficulties in planning extensions and new towns which was quickly observed. Town planning has become

a distinct profession and has been made the subject of much specific legislation. The English Town Planning Act of 1909 is a most stringent measure which gives to a "local government board" in every town in England and Wales almost absolute control of the laying

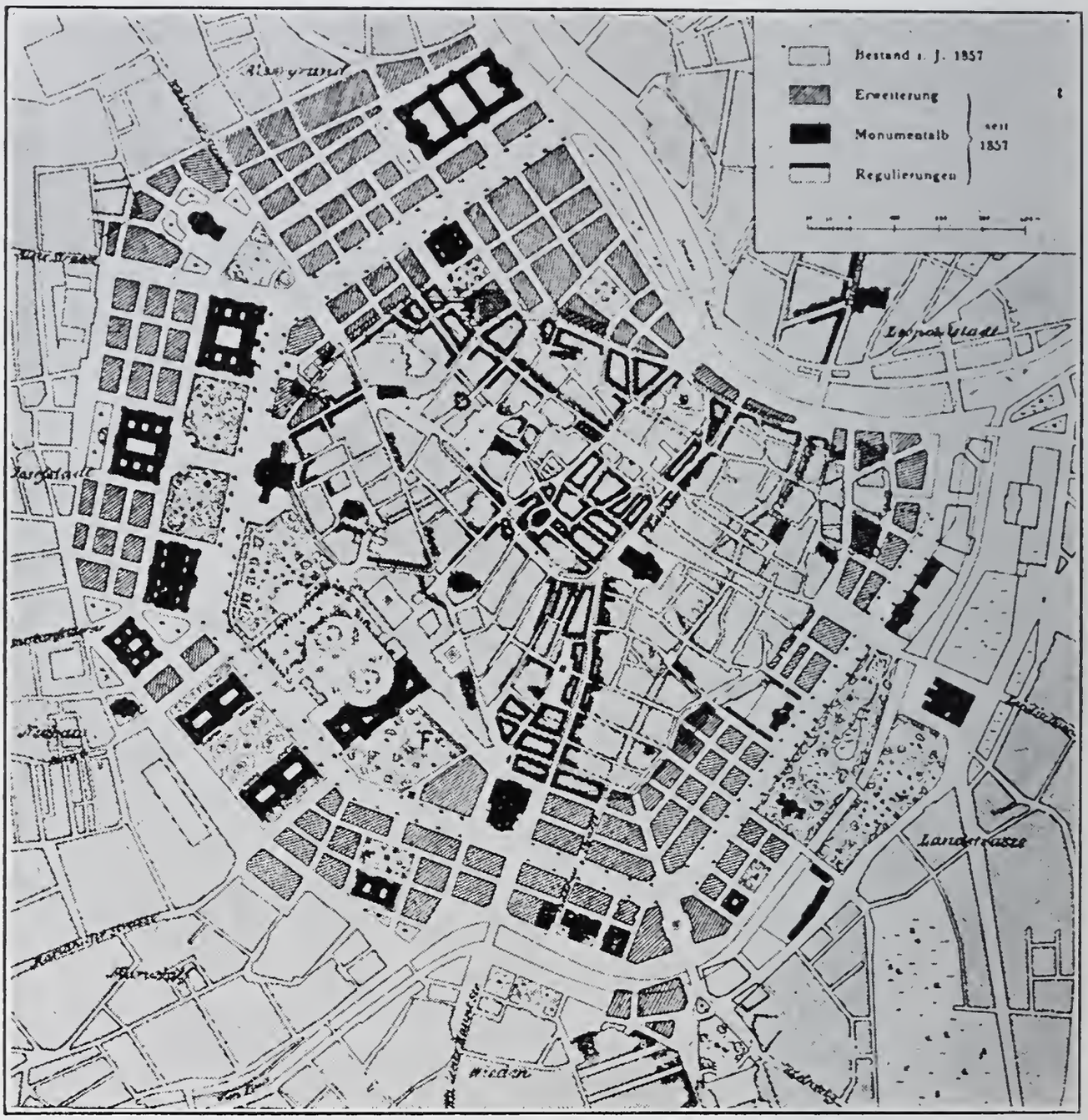

Fig. 10.—Vienna, Austria; plan showing reconstruction on the site of the old fortifications since 1857.—(From "Town Planning Review.")

out of streets and roads, the subdivision of property for purposes of improvement, and even of the improvements themselves. So broad and sweeping is the authority conferred by this act that its practical operation is being very closely watched by every one interested in city planning. The passage of the act was no doubt

largely due to the success in recent years of the "Garden Cities," "Co-partnership Tenants' Associations," and similar enterprises in the vicinities of the large industrial centers, undertaken for the purpose of improving the living conditions of the working classes and encouraging higher ideals of citizenship.

In the cities of Germany the local authorities have complete control of all town planning and improvement, and in many cases considerable property is actually owned by the community and the profits of

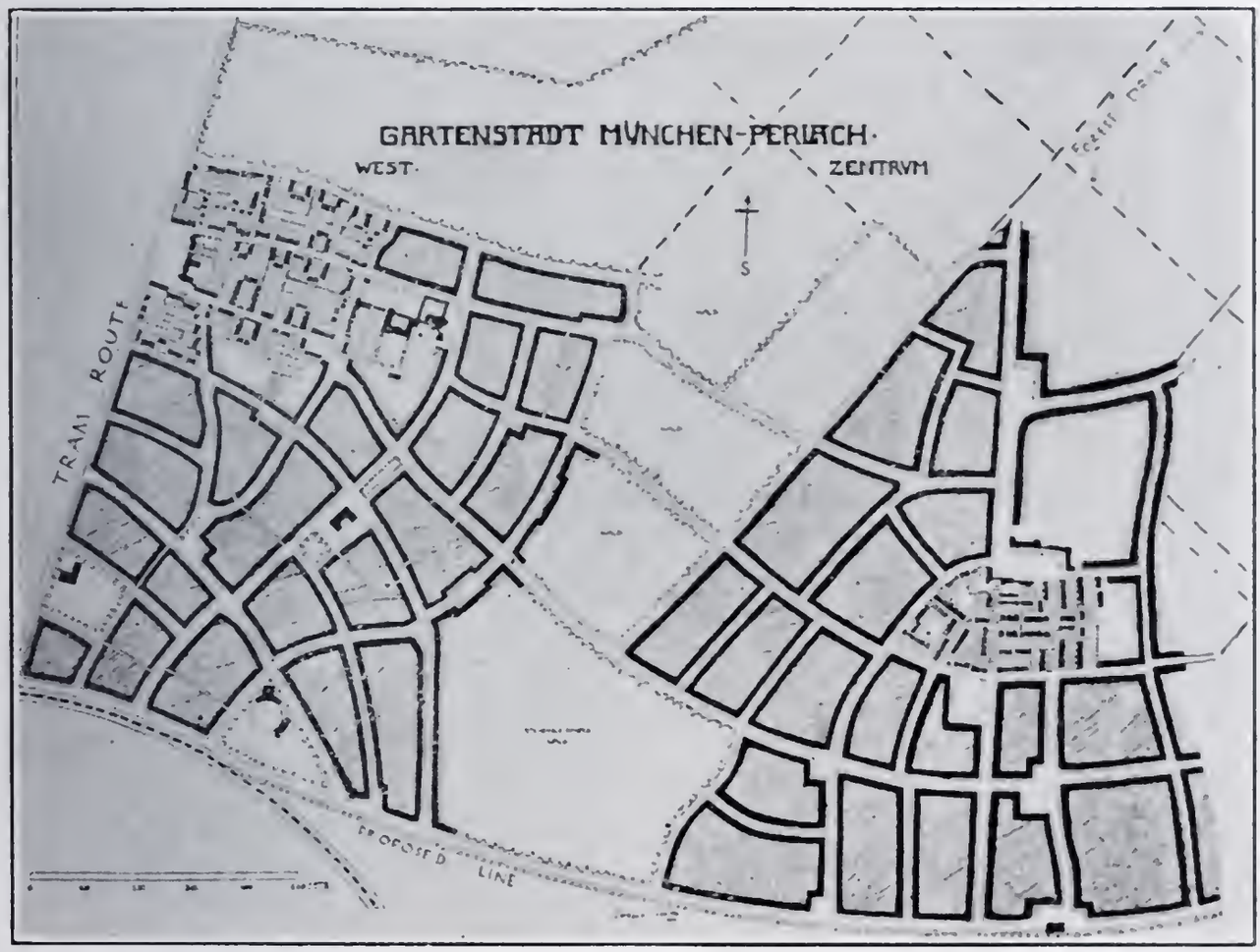

Fig. 11.—A modern German town plan.—(From "Town Planning Review.")

rentals are sufficient to relieve the people from taxation for the support of the community. In some towns the public property is sold, reserving the right to buy it back for the sum paid at any time within one hundred years, and this effectually prevents speculation in land values. In the town of Ulm over 80 per cent. of the total area is publicly owned.

Germany has been even more active than England in the establishment of industrial colonies and garden cities, and has made it a regular

practice, in the laying out of new towns or the extensions of old ones, to plan the street systems far in advance of building operations, and then compel all improvements to conform to the established system.

The opening of a new section for development where the property is not owned by the community is well illustrated by the process in Frankfurt-a-Main. The theory is held that the opening of streets and the readjustment of property lines are necessary for building purposes, and as much in the interest of the property owner as of the general public. The opening of such new streets may be petitioned for by the municipal authorities or by a majority of the property owners affected; a commission of six members acts upon the petition, takes temporary control of all the property affected, determines the total area of each property involved and the area taken by the streets, readjusts the property lines for building purposes, and returns the portions not condemned for street purposes to the original owners in proportion with what they originally held and as nearly in the original location as may be possible. No damages are allowed unless an area exceeding 30 per cent. of a property is taken for public use or unless it is conclusively proved that the actual value of the property has been depreciated by the improvement. In some instances the readjustment is voluntarily agreed to by the property owners and no claims for damages are made where as high as 40 per cent. of a property has been taken.

The practice of creating large open spaces or squares at the intersections of the important streets is very general in all the cities of Europe. The enlargement of such intersections along busy streets is very desirable and advantageous, as it enables travel brought to crossings at a common point to be distributed with much less confusion, and the practice should be more generally adopted in American cities. The enlarged intersections at such well-known points in London as Piccadilly, Oxford and St. George Circuses, and the Elephant and Castle afford the best illustration of their usefulness in relieving congestion, for while the crowding at these points is tremendous by reason of the several lines of traffic crossing each other, conditions are much better than at points where no widening has been effected.

London, however, has not carried this work on so methodically as continental cities, where the spaces have been made sufficiently large not only to relieve all traffic congestion, but also to provide admirable sites for fountains, monuments, and buildings. The great squares

and circles of Paris, upon which have been erected imposing memorials of the men and events which are inseparable from French history, and the broad, open areas surrounding the splendid buildings of a public or semi-public character, contribute very largely to the distinction she holds as the most magnificent city of the world.

In the German cities, in addition to the ample space provided at the intersections of the principal streets, churches, opera houses, and railway stations are especially favored by the great open spaces surrounding them; in fact, it is rare in the new or rebuilt continental cities to find a modern public building of an impressive or monumen-

Fig. 12.—The lake front, Lucerne, Switzerland.

tal type which is not so located as to afford at least one point of view from which its distinguishing features and the complete effect of its architecture may be observed to the best advantage, and this object is generally accomplished by constructing it at a point of convergence of wide streets and opening a great square around it.

A feature of municipal development which has received little attention in America is seen everywhere in Europe. This is the improvement of the water fronts, which, judging from its very general adoption and the apparent age of some of the work, has long been considered an essential part of the development of cities and towns.

The Seine, for its entire length of seven miles within the wall of Paris, is banked with massive walls and bordered by broad avenues with drives and promenades; where necessary to provide for the loading and unloading of boats and barges, a stone-paved quay or wharf has been constructed a little higher than the level of ordinary high-water, and the levels of the avenues are from 10 to 20 feet higher. Stone balustrades and rows of trees usually serve to conceal the quays from the avenues. For the entire distance the banks present a most attractive appearance, and many of the finest and most famous buildings front upon, or stand in full view from, the river.

Fig. 13.—The river front at Cologne, Germany.

The same conditions prevail in all continental cities, although the effect is not always so uniformly pleasing as in Paris. Geneva, Lucerne, and other cities on the lakes of Switzerland present splendid examples of what may be accomplished in ornate water-front development, for there the broad avenues are supplemented with small parks and planted spaces with walks and seats, and overlooking all stand the great hotels and other fine buildings.

The cities and towns of the Rhine all have walled river banks, rising sometimes in a series of terraces, many of them beautifully parked for a width of 200 or 300 feet, except through the commercial

sections. The panorama from the river of such cities as Bonn and Cologne, with their terraces, parks, villas, and hotels, is quite in striking contrast with similar views of the cities built upon the banks of American rivers, where the meanest and most hideous conditions are generally displayed along the water fronts.

Berlin does not possess such large opportunities for striking waterfront embellishment as those cities located upon larger and more picturesque streams, yet the Spree, which is but a small river, and

Fig. 14.—A commercial quay on the Spree, Berlin.

all the numerous canals which traverse the city, are substantially walled and have broad, tree-lined avenues on either side, with lower quays for the landing of merchandise, large quantities of which are constantly coming and going on barges.

London commenced to construct embankments along the Thames almost half a century ago, but the work has been very costly and its progress has been slow. What has been done, however, has been very thorough, and the Victoria and Albert Embankments, with their adjacent avenues and gardens, are among the very best representatives of this class of development in Europe. The former, in the

beauty of its gardens and in the fine character of its massive granite walls and balustrades, is perhaps unsurpassed anywhere.

The development of the street systems and river-front improvements in the cities of England, France, and Germany has been especially referred to because they are somewhat more in the public eye and better known than other foreign cities, and such work has been more actively and systematically conducted in them, but the conditions and processes are common to a greater or less degree in every European city.

City planning and city building in the United States, which in the past have been allowed to drift along in a somewhat aimless, indefinite, and haphazard manner, meeting and satisfying only the immediate needs of a community, have come to be civic problems of vital importance in view of the intensive increase of urban population. The growth of cities has been left too much to chance and to the wish and will of the individual; consequently, there has been little thought or care for the future, and such defects in methods as have been revealed from time to time have received little more than temporary relief. Regulations intended to be corrective have occasionally been enacted, but too often such regulations have run counter to selfish individual interests, and are ignored or evaded.

The past two decades have witnessed a remarkable awakening among those classes of our citizens who have been active in the investigation of sociological problems, among engineers, architects, and artists, and among those charged with the responsible duties of municipal administration, to the necessity for material reforms and improvements in the social and physical conditions existing in our large and rapidly growing cities. Municipal authorities and civic societies have begun to realize that the future requirements of cities and towns have not received the consideration which their increasing importance as great centers of population and industry seems to demand, and a general movement has begun which has for its object the physical development of cities by methods which will insure better facilities for urban intercommunication, provide larger areas and a better distribution of parks and other public places, protect and utilize in a larger degree the water fronts and natural waterways, secure a systematic grouping of public and semi-public buildings, create a larger public interest in civic art, and effect a complete and comprehensive co-ordination of all these necessary adjuncts of a progressive, intelligent, and healthy community.

This movement has gathered force and increased in popularity until at the present time its scope embraces practically all our principal cities; its spread has been almost phenomenal during the past decade, and much earnest enthusiasm has attended its growth and much notable improvement has already resulted from it. It is difficult to say whether this movement was suggested by an appreciation of the wisdom of forestalling the further extension of the faults and evils which were rapidly becoming apparent in our methods of city building, or by the example set by European cities; but however that may be, it is true that our advocates of the new processes draw a large part of their inspiration from what has been actually accomplished abroad.

Whether the inspiration came from abroad or was conceived at home, most of the American cities have undertaken large projects of urban development and embellishment in a vigorous and determined manner. In many instances commissions of expert engineers and architects have been employed to make a comprehensive study of local conditions, prepare a general preliminary plan, and submit a report covering such suggested improvements as may seem feasible, adaptable, and broadly in the interest of the public welfare. In other instances state or municipal legislation has created local boards or commissions to perform similar services, and also to carry their recommendations into effect.

When William Penn founded Philadelphia, the dwellers in European cities still herded in the narrow streets and courts within the city walls; but even at that time the disadvantages of the prevailing conditions were becoming seriously realized, and Penn determined to adopt a radically different plan in laying out his new city. In this he was more foresighted than any of the contemporaneous pioneers of American city building, and his example was adopted and followed in the subsequent planning of most of our cities. The rectangular system, familiarly known as the "gridiron" or "checkerboard" system, which he adopted was a long step in advance of the systems which existed in the cities of his time. Although he had large faith in a great future for his new city, he could not foresee to what extent it was destined to grow or what would be its necessities in the years to come. If, in addition to the rectangular system of streets and parks he laid out, he had provided broad diagonal streets radiating from the square he established at the intersection of the two great avenues in the center of the city, and from the termini of High Street at the

two rivers, his plan, in the general principles involved, would have been a well-nigh perfect one, not only for his time but for the centuries to come.

The rectangular or "gridiron" system has been adopted and followed to a greater or less degree by all American cities. The older ones, New York and Boston, for instance, which had originally followed the practice of European cities of that time in laying out streets, adopted it, although the latter never took to it so seriously as others did. Once adopted, it was difficult to depart from, for it was an

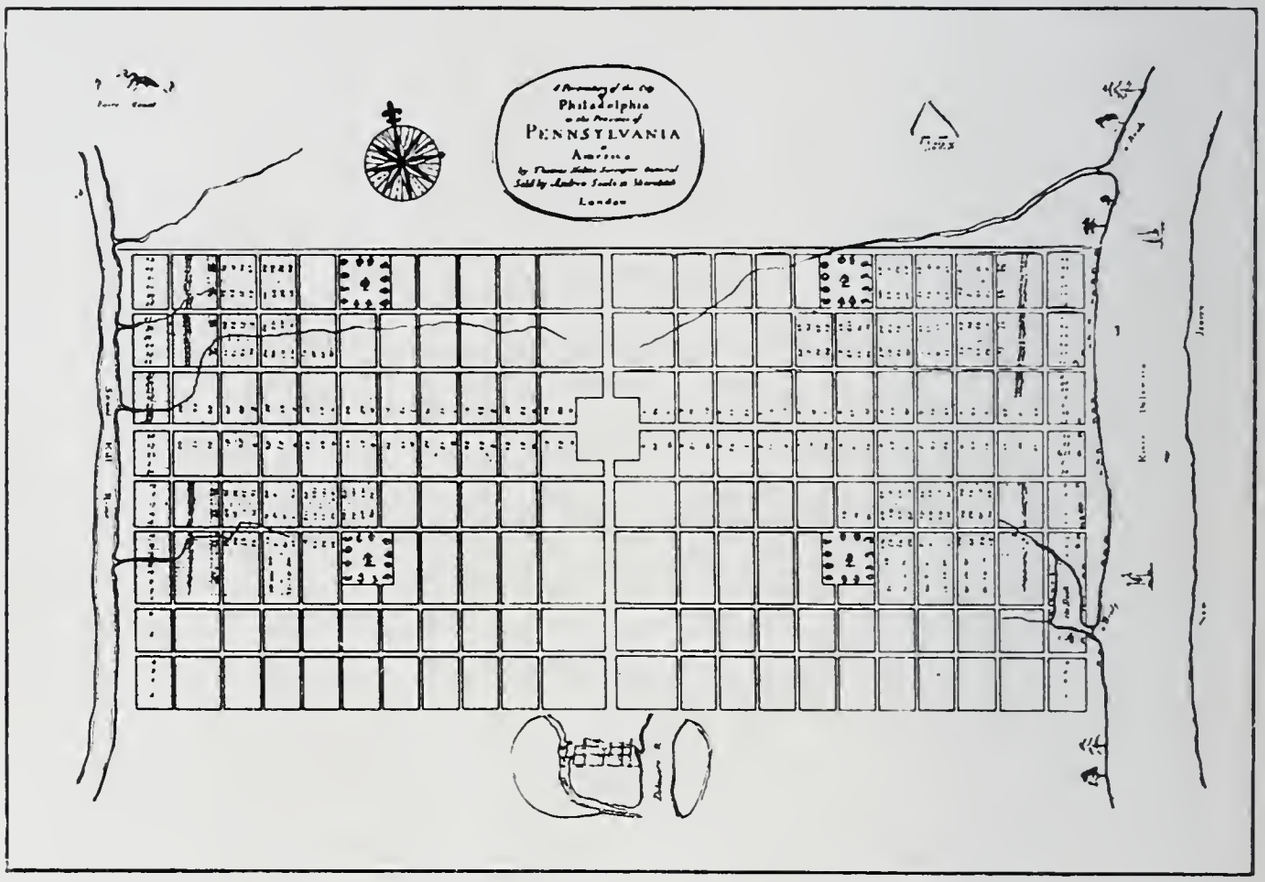

Fig. 15.—Thomas Holme's plan of Philadelphia, 1683.

easy system to follow in the development of our rapidly growing towns, and its defects were not seriously felt until cities began to assume metropolitan proportions and the tremendous progress of their various industries created conditions which it could not fully satisfy. This system, relieved by well-planned diagonals and modified to meet local conditions of topography, is undoubtedly the most practical and economical one; it was adopted for the city of Washington, and as a result it is probable that the street system of that city will need to be changed very little, if any, in the years to come,

unless conditions of trade and transportation should be revolutionized in some manner not conceived of at the present time.

The necessity for relief from the congested conditions existing in many parts of Philadelphia, and particularly in the chief business centers, has come to be very seriously realized, and a number of projects for affording such relief have been suggested, but have not received official sanction. The opening and widening of streets through improved property will be a very costly undertaking, but such action is rapidly becoming essential to the healthy growth of the

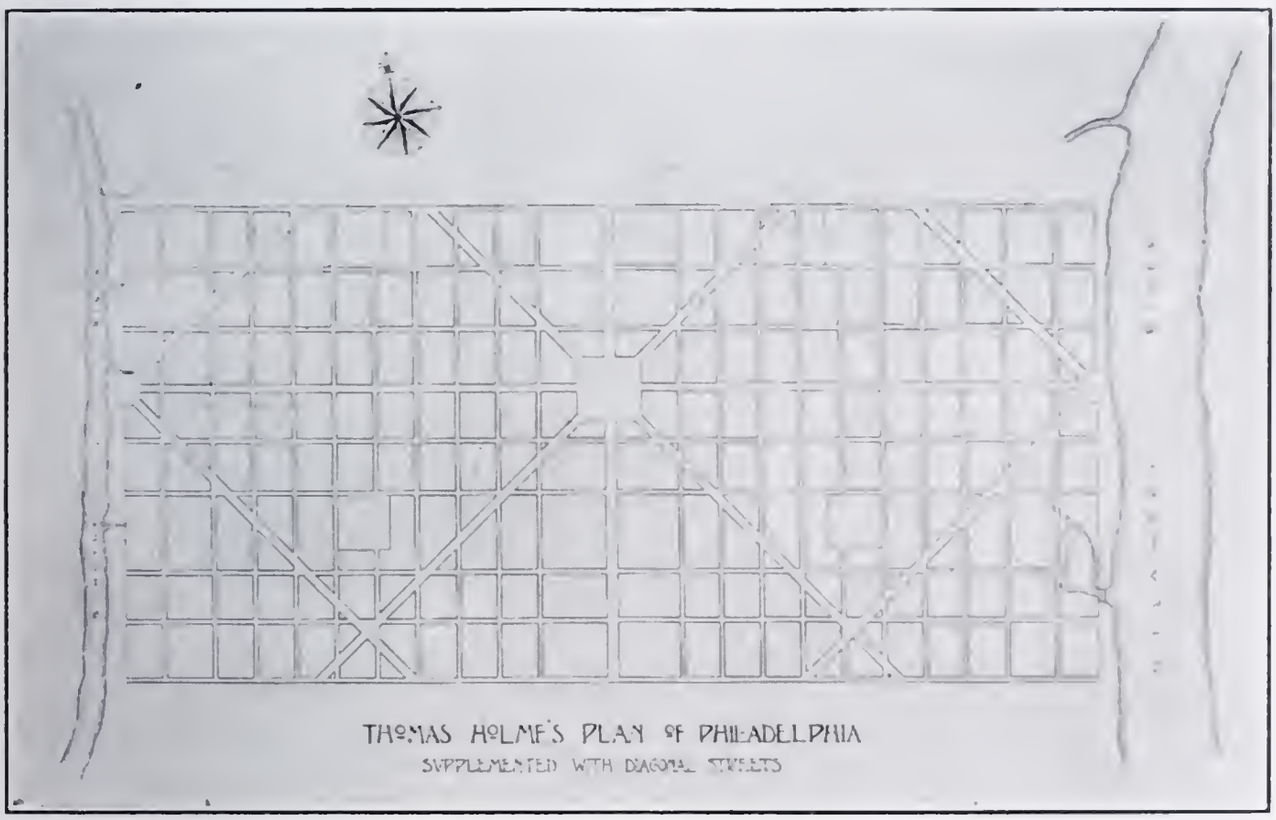

Fig. 16.—Thomas Holme's plan of Philadelphia, supplemented with diagonal streets which would have made it a perfect plan for the twentieth century.

city. A long time will be required to effect the desired changes, and in order that the work may be done in a systematic and economical manner a comprehensive plan based upon a careful study of existing conditions and probable future needs should be established. With such a plan for a base of operations, the physical changes could be made intelligently and systematically in small sections from time to time as funds were made available for such purposes; this is the policy now followed in Paris and recommended by the Royal Commission for London.

The Parkway from City Hall to Fairmount Park, if constructed on

its present confirmed lines, with an eye single to the great substantial advantages and benefits which must accrue to the entire city and to present and future generations of its people, can be made the most magnificent improvement of its class in the world; with an unbroken view of the massive outlines and lofty tower of the City Hall at one end and a splendid Museum of Art crowning the heights at the other, and with handsome buildings of a public or semi-public character surrounding a great square at the western end and adorning both sides of the main avenue, its completion will give to Philadelphia a grand and distinctive feature of monumental proportion and dignity in which all her citizens can feel a just pride and which will contribute more to her national, and even international, reputation as a city of progressive thought and activity than any other municipal work now contemplated. Unless this great work shall be carried out in a liberal, broad-minded, public-spirited manner, free from the obstructive influences of provincial conservatism and a false spirit of economy, instead of an enduring monument to civic intelligence, capacity, and energy, it may stand as a perpetual intimation that our citizens are not equal to great occasions or capable of grasping great opportunities and so shaping them as to reflect a lasting fame and reputation upon the city.

There is, naturally, much honestly intended opposition to and criticism of this project, which is entitled to sincere consideration and respect, but the fact remains, and should be seriously considered by our citizens, that great works of this kind have long been important features in the development of European cities, and contribute very largely to that fascination and attractiveness which annually tempt thousands of Americans to cross the Atlantic and spend millions of dollars in those beautiful foreign cities; also, that nearly all of the cities of the United States are actively engaged in similar undertakings, and that Philadelphia, once the capital and long the most important city of the Union, has, whether justly or unjustly, suffered in her prestige, and should take quick and intelligent advantage of this great opportunity which has come to her doors to regain some of what she may have lost in fame and in fact.

The banks of the Delaware and Schuylkill Rivers should be improved by embankments and broad avenues constructed with a view of improving their attractiveness and providing increased landing and commercial facilities for the port; the practical benefits of such work are well illustrated by what has been accomplished in the widen-

ing of Delaware Avenue and the construction of modern wharves and bulkheads between Vine and South Streets. The banks of the Schuylkill within the boundaries of Fairmount Park have been improved in an attractive manner by the Commissioners of Fairmount Park, but along its lower courses, where opportunities are offered for an improvement which would be both useful and ornamental, nothing has been attempted; the improvement of that portion of the river was first suggested about fifteen years ago, and has been constantly agitated since that time, but nothing tangible has been accomplished beyond arousing and keeping alive a sentiment in favor of it.

All of these suggested projects for extending and improving the street system, for constructing embankments and broad commercial and ornamental avenues along the river banks, and for creating parks, parkways, and open public places, are closely related to each other in the common object of advantageous and attractive development, and general preliminary plans embracing all of them should be established by the proper authorities. The work necessary to carry such large projects of improvement into effect would, by reason of its cost, extend over a long period of time, and the existence of a well-considered comprehensive plan would insure its being done along systematic and uniform lines.

At the two great city planning exhibitions held in Berlin and London in 1910, which attracted engineers, architects, and other interested parties from all parts of the world, the United States was more largely represented than any country except Germany; nothing from Philadelphia was shown, but the new plans for Washington and Chicago were esteemed the finest and most magnificent of the entire collection. Reports as to the character of the exhibits, the attendance, and the interest shown in these events furnish conclusive evidence of a remarkable growth of activity and enthusiasm in the work of city planning in recent years; the comprehensiveness of the plans and the magnitude of the work contemplated by them indicate not only a sharp rivalry among cities for the material things that make for greatness, but also a quickened public sentiment and a determined public demand for the accomplishment of great purposes in great cities which not only expect to remain great but are ambitious to become still greater.

The people of the United States look eagerly forward to the time when Washington, in carrying out and completing the work contemplated by the plan for improvement she has adopted, will be the most

splendid as well as the most influential of the world's great capitals. New York, now ranking second in the list of the world's great cities, is forging ahead to first place through the great works she has accomplished and the still greater ones she is now planning. Chicago has entered the lists as an intensely active competitor for place with New York by commencing the two hundred and fifty million dollars' worth of municipal improvements called for by a new city plan,

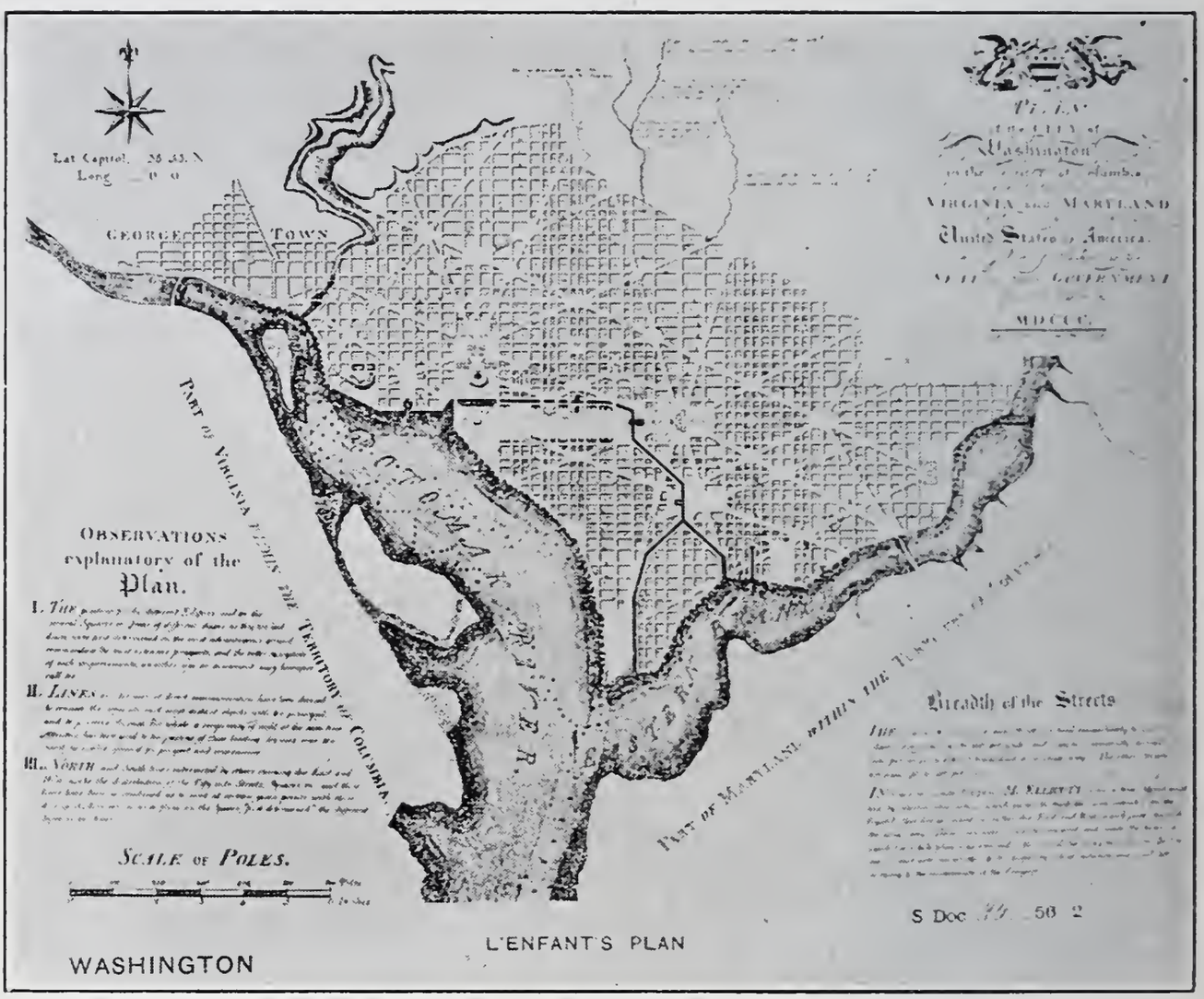

FIG. 17.—l'Enfant's plan of Washington, 1800.

for the preliminary studies and reports of which the sum of eighty thousand dollars was paid. The leading citizens and influential organizations of Boston have prepared a program of progress, and under the popular slogan, "Boston 1915, the finest city in the world," propose to accomplish the transformation of that city during the next five years. About sixty cities and towns of the United States have prepared more or less elaborate plans for improvement and

embellishment, and are busily engaged in doing the great things demanded by the pace of twentieth century progress. Philadelphia must take the same broad view of the responsibilities of the future, and in preparing a comprehensive plan for improvements is placing herself in the position of preparedness for the contest for commercial, industrial, and social supremacy of the coming years.

The fact that European cities are reconstructing their street systems upon modern and progressive lines, that their water fronts are in a high state of both useful and ornamental development, that they are constantly exerting themselves toward still greater civic improvement and civic attractiveness, and that many American cities are bending their energies in the same direction, may not be a sufficient reason why Philadelphia should do the same; but there are other and more potent reasons.

In the natural course of events a city knows no finality; barring any extraordinary violence of nature or of man, it goes on forever; its physical attributes, its progressiveness, its importance and influence as an industrial, financial, and political world-power, are what its citizens determine they shall be. In the days of absolutism cities were made great by the will of ambitious monarchs, and were kept great by equally powerful successors; but progressive modern governments have been emancipated from absolutism, and cities now achieve greatness only through the high ambition, concerted energy, and tireless activity of their loyal citizens. This being true, we must rely for rational and permanent progress upon the larger interest of the people and their broader view of civic problems.

A city can no more be the judge of its own greatness than an individual; it must keep in step with the world in the world's work, and it must win the world's acknowledgment and applause. To do this, it must aim toward higher ideals through every avenue of civic endeavor and civic duty, and it must pursue that aim with tireless energy and devotion. This is what the new departure in city planning means and stands for; it seeks not only finer streets, larger parks, and greater opportunities for industry, but it aims also to raise the standard of citizenship and to make city life more worth the living by providing for the improvement of the social condition and the environment of its people, and by creating a better, brighter, and more beautiful city for all.

Our people are too prone to be content with existing conditions and to give little heed to the call of the future, apparently forgetting the

parts we have to play in the tremendous progress of the greatest industrial and commercial era the world has known. The signs of the times point inevitably toward the accomplishment of large undertakings for the physical improvement and embellishment of cities. The general and almost universal scope and force of the movement indicate that modern progress demands the things involved in it; we must advance and hold our position or we will gradually retreat and relinquish whatever of world-prestige we have won. Either we must undertake these new burdens or admit that we are weak and incapable, and unable or afraid to attempt great things which will assist us in maintaining our position as a really great city.

Again, we need these things; they will be a direct and constantly increasing benefit to us. Every citizen sees and criticizes the faults and defects of our streets; every citizen with a family knows that his children need fresh air and play to stimulate their physical and mental health and growth, and he knows that they cannot find these things in the public streets or diminutive back-yards of Philadelphia; therefore, we need parks and playgrounds. Every well-ordered citizen wants attractive surroundings; in his busy hours he will accomplish more and in his leisure hours he will find greater enjoyment if he can constantly look upon beautiful things; therefore, we should encourage and cultivate a higher order of civic pride and dignity, and insist that in those constructive features of our city over which the people or their representatives exercise control there shall be a proper recognition of the value of art and beauty as well as utility and service. These things pay; Europe is paid millions of good American dollars every year simply because of her beautiful cities, and that flood will increase in volume unless we can find ways and means to keep our people and their dollars more interested at home.

In closing the author wishes to take the liberty of quoting from a recent article in the "Town Planning Review," to which publication he is indebted for several of the illustrations used, and in which Mr. Stanley D. Adshead, Professor of Civic Design in the University of Liverpool, says: "In the contemplation of a city, we have before us the most comprehensive of the works of man; its solid walls tell us of his stubborn will, its fine façades of his success, its twisted streets of his uncertainty of purpose, the squalor of its slums of his defeat. It is in human life that we have the secret of its growth, and man himself is but a reflection of its breadth.

"A city is the greatest of the works of art; written on its walls are the tradition and the history of the past, outlined in its composition is the imprint of the human soul. The city is a great stage, and city building is a real theatrical art. Mellowed in harmonious color and reflecting the soft blue of the sky, the effect of its sunlit walls is such as the most brilliant stage display can but poorly suggest. And yet it is but the background of the citizen who traverses its ways. Great is the city whose architecture is passed unnoticed by the crowd, but not unfelt. Great is its presentment when its more important buildings alone demand conscious attention, leaving the rest but subconsciously felt. Convincing is its merit when the persistent formality of its street is conducive to a sense of respect, and arouses in the heart of the citizen that pride of citizenship alone engendered by civic art.

"Democracy, with its new responsibilities, has grappled with the problems of its youth; it has made mistakes, it has to answer for far-reaching and most disastrous results, but it has passed through the fire. At first, intoxicated with the freedom it had won, it sought but mercenary gain. Cities became factories, and life merely a business concern. Sham respectability became a cloak for truth of expression, and what interest existed in civic design was centered around questions of construction and the importance of hygiene.

"But there has been a change; knowledge has spread, democracy has grown, the modern city awakes to a new dawn, and today it is the democracy who watch with anxiety the growth of towns.

"Most of our larger cities which have grown by leaps and bounds during the period of industrial activity of the latter half of the last century, require pulling down, Haussmannizing, and re-erecting on intelligent lines. This, then, is the work which the municipal authorities and the town planners of the future will be called upon to undertake, and it is in the carrying out of such undertakings that an appreciation of what ought to be will be found necessary before dealing with what is."

DISCUSSION.

Leslie W. Miller (Visitor).—I cannot add anything whatever to this admirable presentation of this subject. I will say, however, that this is a presentation of the things that have got to be learned, of the lessons that have got to be applied, before a city with any pride at all can be satisfied with itself, and until those things have been learned, and until those lessons have been applied, you cannot be sure that you are on the right track. There is only one way of doing

these things; and there is no question as to which is that right way. It is a question of looking at things intelligently, and planning for the future. Philadelphians have not to be convinced of the necessity of city planning. It is not so much the particular way in which it is proposed to do anything that we want to discuss, as to insist upon the importance of the planning itself. It is the plan we are after, and I would like to have every such audience as this addressed by just such people as Mr. Haldeman, until this whole city is absolutely convinced of the practicability and economies that will result from this effort to look ahead and plan for the future.

Mr. Frank Miles Day was telling me just recently that he was in Washington, and in talking of this same subject with speaker Cannon, Uncle Joe at once asked him how much the proposed improvements to Washington were going to cost. "Oh! 'Two hundred million dollars!" "Where are you going to get the money?" to which Mr. Day replied: "Will you be kind enough to tell me how much money Washington is regularly spending now on permanent improvements—you have to get new streets and acquire land for park purposes, and other expenses which have to be met anywhere; how much money is Washington spending on permanent improvements?" "Oh, about ten million dollars a year." "And our plans expect to take up perhaps two hundred million dollars in twenty years. You are spending it any way, but you have been doing it without any very definite purpose in regard to the future. We are only asking that the same amount which you are spending now be spent in accordance with a plan that will get you somewhere in twenty years." I went to City Hall the other day and asked the City Statistician how much money we are spending on improvements, and he told me about ten million dollars a year. That is about thirty million dollars in the three years that Mayor Reyburn has already had, and the question is, then, whether, at the end of twenty years, we shall have done the best we could. Shall we have to say, for example, "Well, we might have bought that whole beautiful valley that has been sacrificed to our checkerboard system for a park for the same amount of money and run the lines of improvement where they ought to be, or have done equally foolish things in other directions that a little foresight would have enabled us to avoid." That is all that the advocates of comprehensive city planning are driving at; they are pleading not for more money, but simply for the principle that we shall know what we are about; that the needs of the future city shall be anticipated with a little intelligent foresight. How is it that we never look any way except backward, and take no account of time except by its loss. All that the planners are pleading for is that we shall look ahead. We know about where the city will be in twenty years from now. We can also tell about what is going to be needed, and we want to interest the people in a plan that can and will be intelligently worked out for the development of a city that will not have to be too radically revised.

And let me say once more what I said the other night to this very audience. We want guidance. I repeat what Mr. Haldeman has said so many times tonight; the guidance that he has oftenest referred to is the one I pleaded for the other night: "How is the thing going to look?" If it is going to be any eyesore, we do not want it. Project it as only the architect and the artist can project it, as only the man with imagination can do it, and see "how it is going to look," and we can grasp it in advance and see if it is the sort of thing we want. It will

then be the city beautiful, and if it is that it will also be the city healthful and the city happy. God hasten the day when Philadelphia will be the city beautiful of America.

John C. Trautwine, Jr.—Nothing stands out more clearly, from Mr. Haldeman's paper, than the overwhelming advantages accruing from united effort, as distinguished from individual effort—the immeasurable superiority of public to private wealth.

At great cost, the millionaire may buy automobiles, great pictures, palaces, and other toys; but what are these, compared with the virtual ownership of all the street systems of all the world, which the poorest of us gets in return for a ridiculously small contribution to the common wealth?

One would suppose that, at this stage of the world's progress, every one would recognize these facts; yet, in a recent issue of a Philadelphia morning paper, a correspondent (manifestly a person of "wealth") broke out with the cry, "Taxes, taxes, nothing but taxes," and referred approvingly to "the great Christian statesman," Kaunitz, of Austria (who died more than a century ago), as having laid down the proposition "that the welfare of any nation did not depend on the income of the State but on the individual property of its inhabitants"; than which, as Mr. Haldeman's paper has shown us, nothing could be more preposterously contrary to the truth.

Paper No. 1100.

THE NEW YORK STATE BARGE CANAL.

WILLIAM B. LANDRETH.
(Visitor.)

Read April 15, 1911.

The State of New York, connecting as it does the valley of the Hudson River with Lakes Erie and Ontario on the west and northwest, and the St. Lawrence River in the north, contains within its borders the lowest passes between the seaboard and the Great Lakes.

The Indians and early traders traveling toward Canada followed the Hudson River northward to Fort Edward or Glens Falls; then entered the Lake Champlain watershed by a carry to Wood Creek, and passed down that stream into Lake Champlain, or by a carry to Lake George, and thence by its outlet into Lake Champlain. Those traveling westward ascended the Mohawk River to Fort Stanwix, at the site of the city of Rome, thence by a short carry to a tributary of Fish Creek entered the watershed of the Oswego River and passed through Oneida Lake, Oneida River, and the Oswego River into Lake Ontario. They also reached the Finger Lakes in the south central part of the State from the Oswego River by ascending the Seneca River and its various branches. Over these routes passed many parties of Indians or whites bent on war raids or in the peaceful pursuit of trade.

Early in the eighteenth century attempts to improve the methods of water transportation on this continent were begun when Catholic priests began to build a canal around the rapids in the St. Lawrence River near Montreal, Canada.

In the latter part of the eighteenth century the building of a canal between Albany and Buffalo was seriously contemplated. George Washington was a strong advocate of this project, and early in the agitation of the matter made a trip from Albany by way of the Hudson River, Mohawk River, Wood Creek, Oneida Lake, Oneida and Seneca Rivers, to Seneca Lake. On his return he stated that he hoped the people of the State of New York would not fail to improve the great natural water-courses in the State. Thomas Jeffer-

son, on the other hand, said that it was madness to attempt the building of a canal from Albany to Buffalo, while Madison thought that the cost would exceed the resources of the entire United States, and so refused national aid to the project.

The first attempts to improve the inland navigation of New York State by the construction of locks and connecting canals were made about 1791 by private companies. These companies soon encountered financial difficulties, and about 1808 the policy of constructing canals in New York State under State aid was inaugurated.

The original Erie Canal had a bottom width of 28 feet and a depth

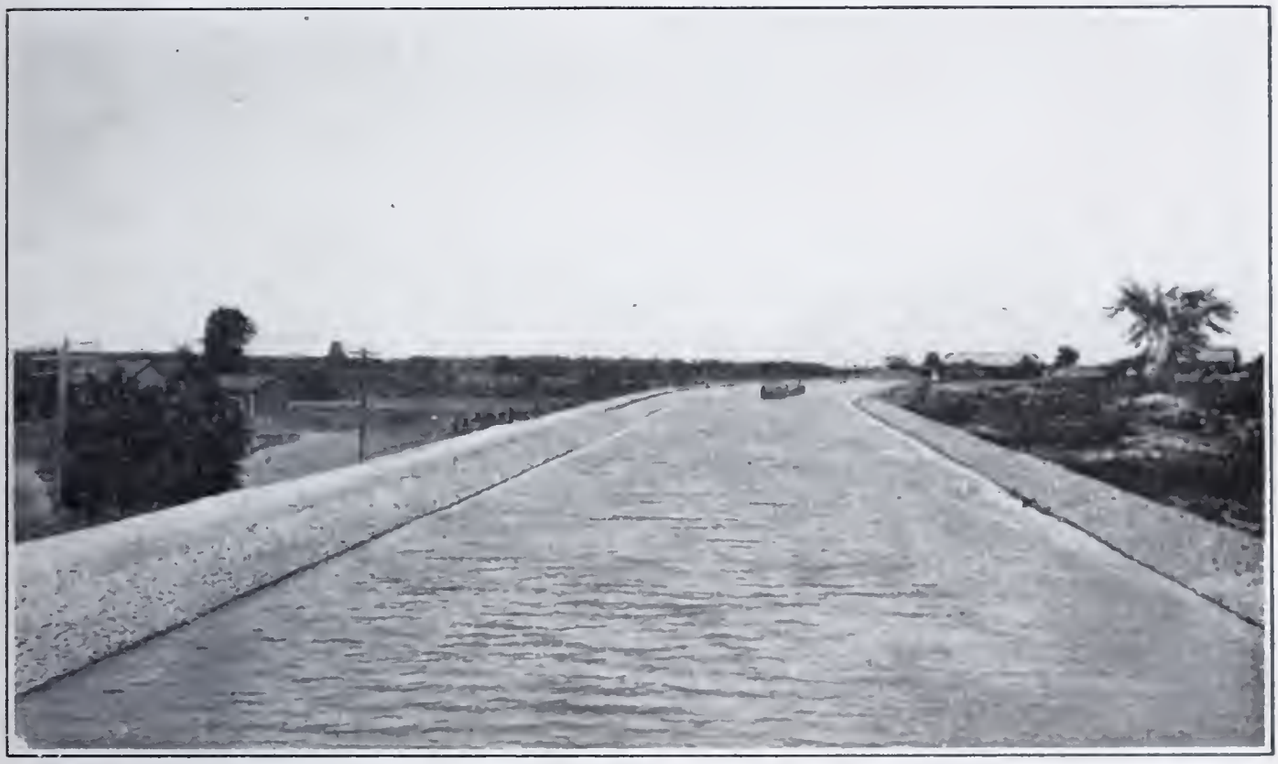

Fig. 1.—Finished canal prism east from Longs Branch.

of water of 4 feet. At successive times the bottom width of the canal was increased to $53\frac{1}{3}$ feet and the minimum depth to 7 feet of water, and until the inauguration of the so-called "barge canal" these were the ruling dimensions. On the barge canal the governing dimensions are in land lines, 75 feet, on the bottom in earth, 94 feet in rock; with river sections varying from 150 feet to 200 feet, all with a minimum depth of 12 feet. When the canals were enlarged, the tonnage of the boats increased necessarily from thirty tons for the first canal to eighteen hundred tons for the barge canal. Correspondingly, the dimensions of the locks increased with the increase of section.

On July 4, 1817, the first Erie Canal construction work was started, and October 26, 1825, was finished. The actual cost of the original canal was a little more than $7,000,000. In August, 1836, the first enlargement was begun, and completed September 1, 1862, at a cost of $31,834,000. While the first enlargement was being carried out, various branch canals, such as the Champlain, Oswego, Cayuga and Seneca, Chemung, Chenago, Black River, and Genesee Valley Canals, were built.

A partial enlargement of portions of the various canals was made

Fig. 2.—Canal prism.

from 1896 to 1898, under what is known as "the nine million" appropriation, that amount being fixed by a constitutional convention when the State Constitution was revised.

Preliminary considerations, discussions, and surveys of the barge canal took place from 1899 to 1903. In 1904 the actual preparation of the final plans was begun.

The first barge canal contracts were let in April, 1905, although, owing to unavoidable legal delays, the active construction work did not begin till late in that year.

What is popularly known as the "barge canal" when completed will consist of four canals:

1. The Erie Canal, extending from the Hudson River at Waterford to Lake Erie at Buffalo.

2. The Oswego Canal, extending from the junction of the Oneida and Seneca Rivers through the Oswego River to Lake Ontario.

3. The Champlain Canal, extending up the Hudson River from Waterford to Fort Edward, then across country to Lake Champlain.

4. The Cayuga Canal, connecting the Erie Canal with Cayuga and Seneca Lakes.

The Erie Canal leaves the Hudson River at Waterford and ascends from the Hudson River to a point above the Cohoes Falls on the Mohawk River by a series of five locks. It then proceeds up the Mohawk River through a series of artificial lakes to a point near Utica. The route then passes across country to the head-waters of Wood Creek, down that creek to Oneida Lake, westward through Oneida Lake, down the Oneida River to its junction with the Seneca River. Proceeding westward, the canal ascends the Seneca River, Clyde River with its branches, to Fairport, about twelve miles east of Rochester. From this point the canal crosses the Arondequoit Creek valley, cuts through high ground to the Genesee, crosses that river, and proceeds westward, crossing various streams, to Lockport. From Lockport the canal cuts through a rock formation to the Tonawanda Creek, and follows that creek to its junction with the Niagara River at Tonawanda.

The elevation of the principal points on the Erie Canal above sea-level are as follows: Hudson River at Waterford, 14.5 feet; summit level near Rome, 420 feet; crossing of Oneida Lake, 369.89 feet; junction of the Seneca and Oneida Rivers, 363 feet; crossing of the Genesee River at Rochester, 512 feet; Niagara River at Tonawanda, 565.55 feet. It will be seen that the Erie Canal in passing across the State in a distance of 353.5 miles ascends from 14.5 feet to 565.55 feet above sea-level.

The Oswego Canal leaves the main canal at Three River Point at the junction of the Seneca and Oneida Rivers, passes north down the Oswego River to Lake Ontario, a distance of 22.6 miles, with a fall of 118.6 feet, to the lake.

The Champlain Canal rises from elevation 14.5 feet in the Hudson River at Waterford to elevation 140 feet on the summit level at

Fort Edward, and then ascends to elevation 96.5 feet at Lake Champlain.

The Cayuga-Seneca Canal rises from elevation 374 feet at the Erie Canal to elevation 381.5 feet at Cayuga Lake and to elevation 445 feet at Seneca Lake.

The Federal Government is making preparations to connect the barge canal at Waterford with tide-water at Troy by building a new dam in the Hudson River at Troy and deepening that river at Waterford.

The existing Erie Canal follows mostly along the sides of the various streams, and in many cases is 30 or 40 feet above the water therein.

The barge canal takes advantage of all streams and bodies of water encountered on the route, and is really a canalization of the various streams and rivers encountered. About three-fourths of the entire distance of the barge canal passes through lakes and streams. The general plan of construction of the river sections is by building dams across the various streams, forming artificial lakes, the boats passing from one lake to the adjoining ones through masonry locks.

Dams.—In rivers subject to heavy floods and ice jams, especially the Mohawk River, the form of dam to be used has been the subject of much study.

A careful examination of existing dams in this country and in Europe has convinced the engineers that the best form of dam for the Mohawk River is what is known as the "bridge dam." This type of dam consists essentially of a bridge crossing the river, having suspended from its lower chord steel struts, the lower ends of which rest against a concrete sill in the river bed. When it is desired to close the dam, steel shutters are placed against the struts, raising the water to the height required for navigation. On the approach of a flood a sufficient number of shutters are removed to enable the surplus water to pass by the dam. In case of a heavy flood and at the end of a season of navigation, all the shutters and struts are raised and the river flows unobstructed under the bridge. The river is thus unobstructed in the flood season and held in pools or lakes in the navigation season.

This type of movable dam is in successful use on the Moldau River in Europe. Two of the bridge dams are now completed and several more will be finished early the coming summer.

A segmental dam turning on a horizontal axis has been in operation

on the Champlain Canal at Whitehall, and another is under contract at Phoenix on the Oswego Canal. These segmental dams are used to maintain the pool level during the navigation season, and are really regulating gates in dams used for power and canal purposes.

For fixed dams a gravity type is used, either straight or curved in plan, with an ogee form of down-stream face. The height of the fixed dams varies from 6 feet at the Caughdenoy dam in the Oneida River to 90 feet for the reservoir dams at Delta and at Hinckley.

Fig. 3.—Bridge and movable dam.

Water-supply.—The Erie Canal from Tonawanda to Three River Point will be supplied by water mainly from the Niagara River, and supplemented by additional supplies from a series of lakes known as the "Finger Lakes," tributary to the Seneca River. The summit level at Rome will be supplied from existing reservoirs south of the Erie Canal between Syracuse and Rome, and also from new storage reservoirs on the Mohawk River at Delta and on West Canada Creek at Hinckley; water from the latter reservoir being carried down

West Canada Creek for a few miles, and then by new conduits across the divide into Nine Mile Creek, a tributary of the summit level.

The summit level of the Champlain Canal at Fort Edward will be supplied from an existing feeder taking water from the Hudson River at Glens Falls.

The Oswego Canal is a canalization of the Oswego River, and requires no other supply than the river, and the same is true of the Cayuga and Seneca Canal.

Fig. 4.—Type of fixed gravity dam.

The reservoirs at Hinckley and Delta have the following dimensions:

HINCKLEY RESERVOIR.

Capacity	24,768,600,000 gallons.
Area of watershed	372 sq. miles.
Area of reservoir	4.46 sq. miles.
Height of dam from lowest point of foundation to crest	90 ft.
Maximum depth of water at dam	75 ft.
Average depth of reservoir	36 ft.

DELTA RESERVOIR.

Capacity	20,570,000,000 gallons.
Area of watershed	137 sq. miles.
Area of reservoir	4.33 sq. miles.
Height of dam from lowest point of foundation to crest	100 ft.
Maximum depth of water at dam	70 ft.
Average depth of reservoir	23 ft.

Excavation.—The total amount of excavation to be removed for the construction of the canal is estimated at 90,000,000 yards, of which about 10 per cent. is rock.

Many and varied types of excavating machinery are used on the various contracts. The stripping of embankment areas and other light excavation has been done on some contracts by the use of graders propelled by sixteen or twenty horses. Various types of drag scrapers, operated either from stationary towers or revolving derricks, are used. The maximum height of tower for this purpose is ninety feet.

Steam shovels of varying weights and capacities, with their necessary equipment of locomotives and cars, are in use. In drilling the rock, common forms of steam or compressed air drills are in general use, although on certain contracts well drills cutting holes varying in diameter from 2½ inches to 4 inches have been successfully operated. On Contract No. 1, in the Hudson River, the rock consists of shale, and is broken by a Lobnitz rock-breaking machine. This consists of a steel hammer 20 inches in diameter, 16 feet long, weighing about 16 tons. The hammer and the necessary machinery, boilers, etc., are carried in a large scow held in position by guy-lines to anchors or objects on shore. The hammer is suspended by a steel cable passing over a sheave attached to the drum of a hoisting engine.

The operation of the rock-breaker is as follows: The cables are fastened and the hammer brought over the ledge of rock to be attacked. The hammer is lifted about 6 feet and allowed to fall, the operation being repeated until the rock at the bottom is presumably shattered. The boat is then moved from two to four feet, and another hole drilled, it being assumed that the rock between the two holes is so shattered that it can be easily removed by a dipper dredge.

Hydraulic dredges are in use at various points on the canal; among others, on the Champlain Canal, Wood Creek, the Hudson River, Seneca, Oneida and Clyde Rivers, at the east end of Oneida Lake, and in Tonawanda Creek.

Most of the dredges have suction pipes 20 inches in diameter.

The largest output of any dredge is 500,000 yards in one month, working three eight-hour shifts daily.

The dipper dredges used vary in size and power, depending on the nature of the material to be removed. At the west end of Oneida Lake and various points between Rochester and Lockport, ladder dredges are in use, by which the excavated material brought up by the buckets is deposited on belt conveyors and thus carried ashore.

On Contract, No. 12, at the west end of Oneida Lake, the material is deposited 165 feet from the end of the dredge proper.

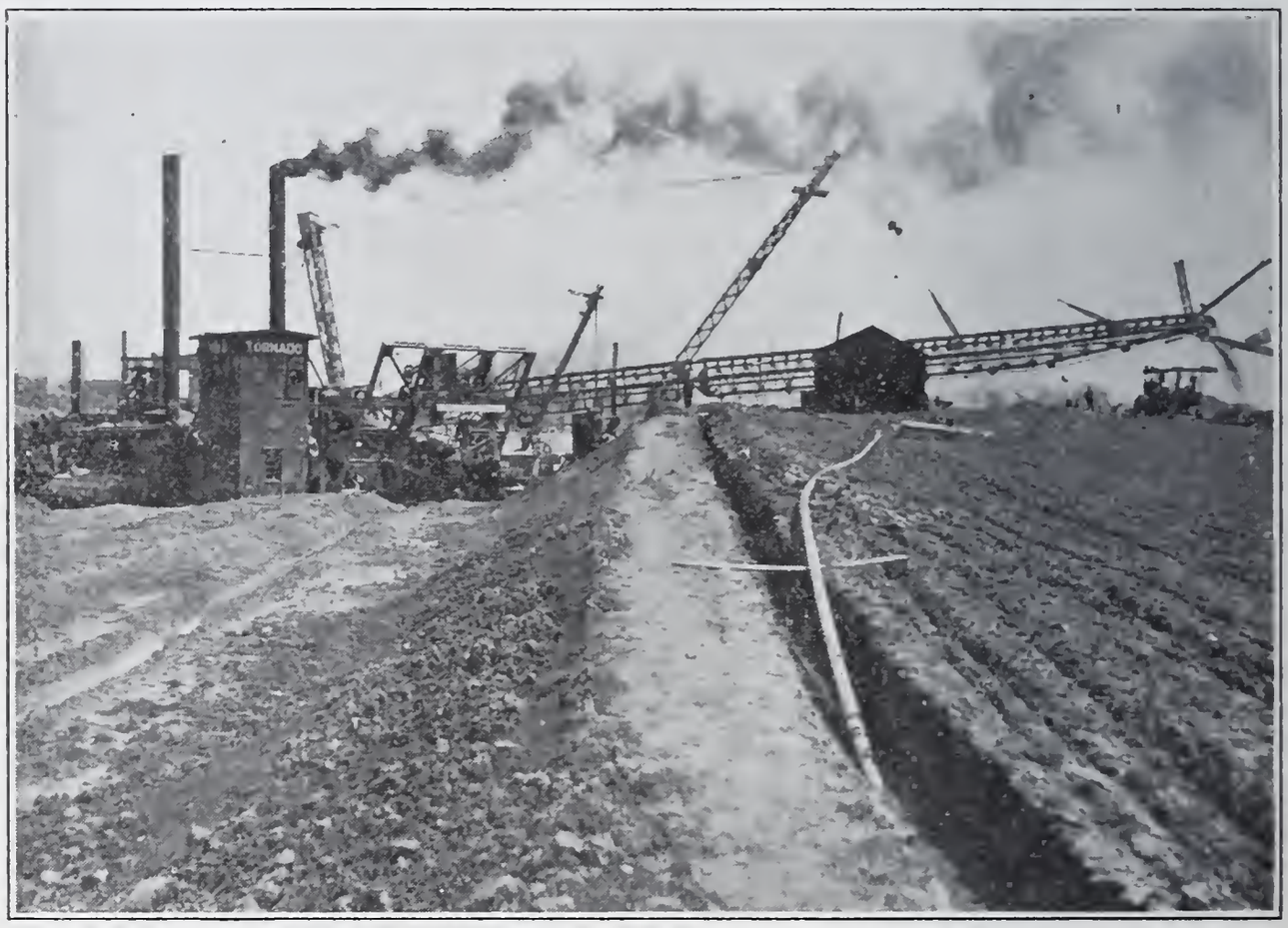

Fig. 5.—Dredge No. 2, at work.

On Contract No. 6, at Rochester, a depth of from 20 to 35 feet of limestone and shale rock is encountered. By reason of the depth of cut and the elevation of the spoil, the machine used must be able to lift its load of broken rock a height of from 70 to 80 feet from the bottom of the cut, free and clear of all intervening machinery or obstructions, and carry it rapidly to either bank as needed. For this purpose a conveyor consisting essentially of a cantilever bridge mounted on two towers 188 feet apart is used. (See Fig. 2.) The

framework of the bridge is of an ordinary type, supported by two towers 90 feet high. Each tower rests on a 60-foot rigid wheel-base made of steel girders which rest on the axles of 33 standard car-wheels. The car-wheels run on standard gage tracks laid parallel to the sides of the canal.

For the removal of the loosened material a bucket known as a "grab" bucket is used. The hinged bucket, being loaded, is hoisted by cables and attached to a trolley running on the lower chord of the

Fig. 6.—Cantilever excavator at work.

bridge. The material is deposited on spoil banks on either side of the canal. From one and one-half to two minutes are required for a round trip of the bucket. The jaws of the bucket when opened cover a space 20 feet long and 10 feet wide, and when closed it has a capacity of about 8 cubic yards.

On Contract No. 40, west of Lockport, a cantilever crane mounted on a single tower running on the canal bank is used. The crane has the following dimensions: Length over all, 382 feet; total trolley travel, 366 feet; height from base of rail to top of cantilever, 68 feet.

The total reach of cantilever from end to end is 428 feet; the extreme height, 92 feet.

A Brown hoist automatic dumping shovel bucket is operated from the cantilever, and the material excavated is deposited on the adjacent spoil banks without any interference to traffic passing in the canal. The maximum monthly output for this machine, working three eight-hour shifts daily, has been 55,000 cubic yards.

On another portion of this contract a double-boom excavator was placed in service about a year ago. This machine is operated

Fig. 7.—Double-boom excavator.

with a 5-yard skip on each boom, and has the skip bails so arranged that it is not necessary to unhook the skips in order to load them. The machine weighs about 150 tons and has two 100-foot booms, which when elevated at an angle of about 28½ degrees to the horizontal, have their tip ends at a horizontal distance of about 100 feet from the center of the machine, so that the reach is practically 200 feet. It is designed to lift and carry a load of 10 tons, including the weight of the skip, on each boom simultaneously, or to operate a 2½-yard drag scraper bucket on one boom. The machine is mounted on skids and rollers and is moved along the canal by throw-

ing the drag bucket forward, getting a firm bite, and pulling on the drag line. The machine was designed to make thirty complete revolutions in an hour, which would mean the loading and discharging of one 5-yard skip every minute. In practice, owing to the natural limitations of the steam shovel, this rate cannot be attained, as the shovel cannot equal the capacity of the excavator. In a mixture of earth and rock the best record time thus far has been about 24,000 cubic yards in 32 eight-hour shifts. Three men are required for the operation of the machine—one to control each of the boom engines and the third to run the rotating engine. Five other men are required to advance the track for the machine, and one man is placed in the canal prism to signal the operators. The machine is operated by compressed air received from a central plant with a pressure of 80 pounds to the square inch at the machine.

Structures.—Many methods of mixing and transporting concrete are in use. On several of the contracts the gravity Haines mixer is used, while on others various types of mechanical mixers are in operation. The concrete is transported and deposited generally in buckets running on narrow-gage cars or by boom derricks.

On Contract No. 11 the ingredients for concrete are raised to the top of a Haines mixer by means of belt conveyors, and the mixed concrete is conveyed from the mixer a maximum distance of 817 feet over a succession of belt conveyors. On arriving at the end of the belt conveyor, the concrete is placed in the forms by lateral belt conveyors or through pipes.

On barge canal masonry structures Portland cement concrete only is used. The proportions of the ingredients of the concrete are as follows:

First-class concrete—1 part cement, 2 parts sand, and 4 parts crushed stone.

Second-class concrete—1 part of Portland cement, 2½ parts of clean sand or crusher dust, and 5 parts of crushed stone or gravel.

Third-class concrete—1 part Portland cement, 3 parts clean sand or crusher dust, and 6 parts of crushed stone or gravel. All of the ingredients are measured in loose bulk.

The tests for tensile strength of Portland cement for a mixture of three parts by weight of crushed quartz and one part by weight of Portland cement are as follows:

At the end of seven days, at least 150 pounds per square inch; at the end of twenty-eight days, at least 240 pounds per square inch.

The separate samples must show an increase of strength in the twenty-eight-day test over the results secured in the seven-day test.

Locks.—The barge canal locks have lock chambers 45 feet wide, a usable length of chamber of 310 feet, and a minimum depth of water of 12 feet. All of the locks but one are to have mitered swing-gates, the exception being the lower gate of the lock at Little Falls, which has a solid lift-gate.

A large majority of the locks have lifts from 16 to 20 feet. The

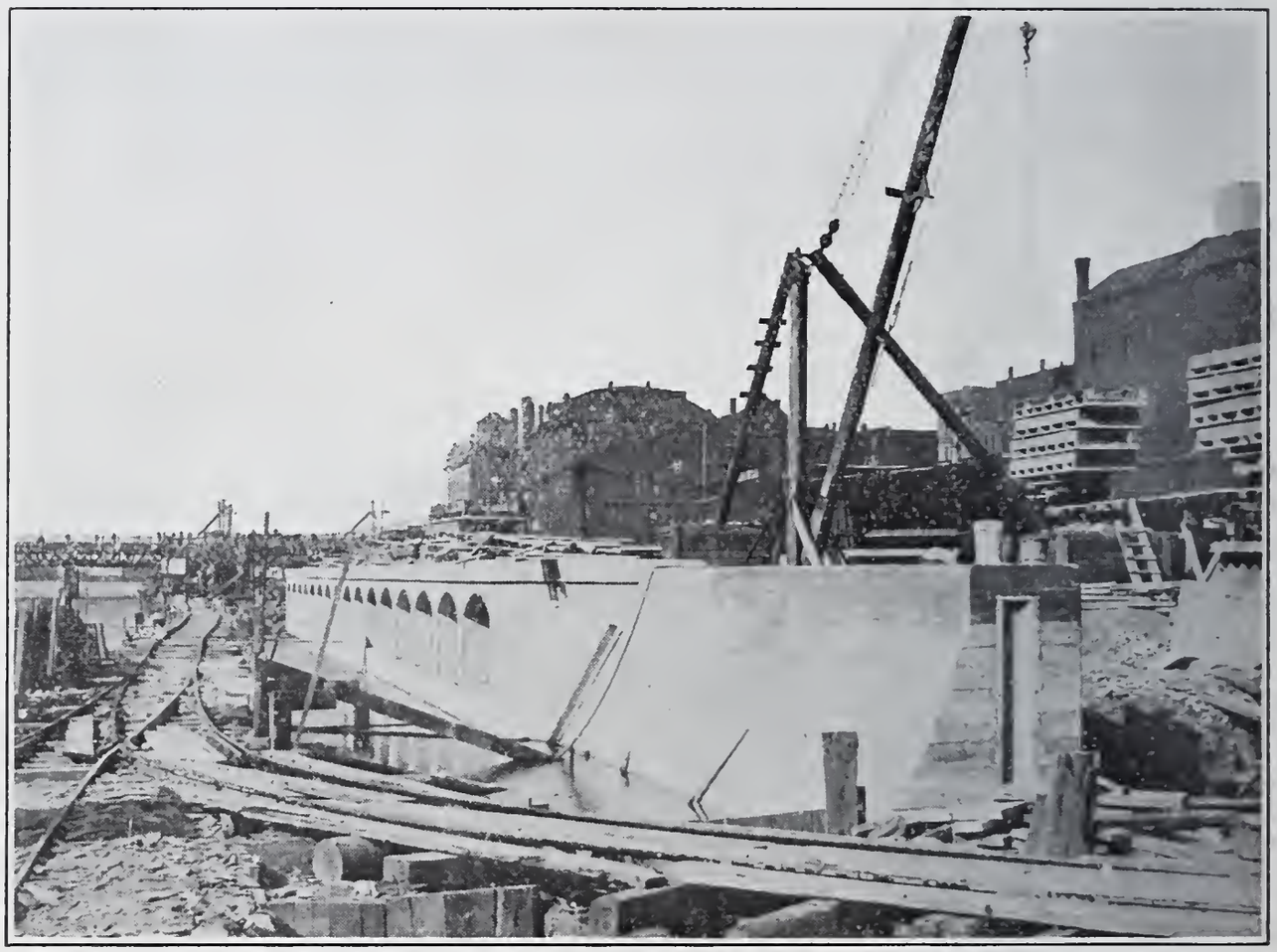

Fig. 8.—Rear view retaining wall, Lock No. 8.

five locks at the Waterford flight of locks have lifts of 34 feet 6 inches each, and the Little Falls lock a lift of 40.5 feet. The locks at Waterford exceed in lift any existing mitered gate locks in the world. The chambers of the locks are filled and emptied through ports in the side walls connecting with the conduits, and the flow is governed by vertical lift valves, with the exception of one lock at Oswego, where the chamber is filled and emptied by siphons.

The siphon lock designed by Mr. D. A. Watt, M. Am. Soc. C. E.,

Supervising Engineer, at Oswego, is modeled generally after similar locks in use on the Elbe Canal in Germany.

In these locks the culverts are built with siphons, but the lock gates are operated by an ordinary mechanical device. Briefly described, the operating principle comprises a culvert in each wall, the portion near each end being turned up to form a closed siphon. The crown of each siphon communicates by means of pipes with a tank placed high in the wall, arrangements being made to fill the tank from

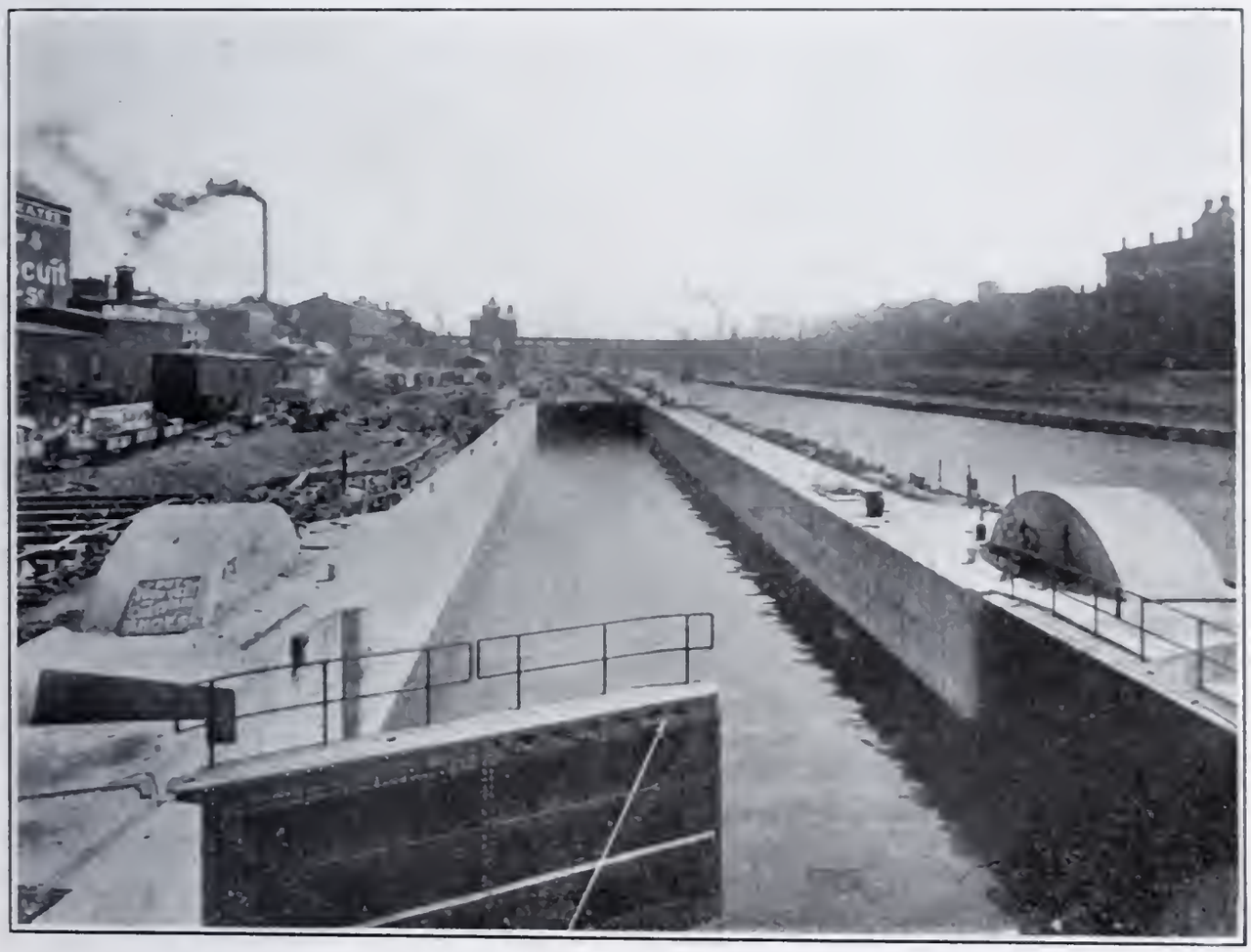

Fig. 9.—View south from Bridge Street, Lock No. 8.

the upper pool when required, as well as to empty it into the lower pool. After the tank has been filled, it is shut off from connection with the upper pool and with the outer air, and the emptying valve is then opened. This has the effect of suspending the water in the tank, so to speak, and thus creating a tendency to vacuum. On connecting a siphon with the tank, the air is drawn out of the former and the water rises over the crest and soon fills the neck. When it runs full, it reverses the draft and draws the air back from the tank

and carries it out with the flow, filling the tank again and restoring the vacuum automatically. The flow in the siphon can be checked or stopped at any moment by opening a small valve communicating with the outer air.

All of the lock gates are of steel, and they, as well as the various valves, capstans, and other appliances at the lock, will be electrically operated. At nearly all of the locks turbines will be installed for the generation of the electricity needed.

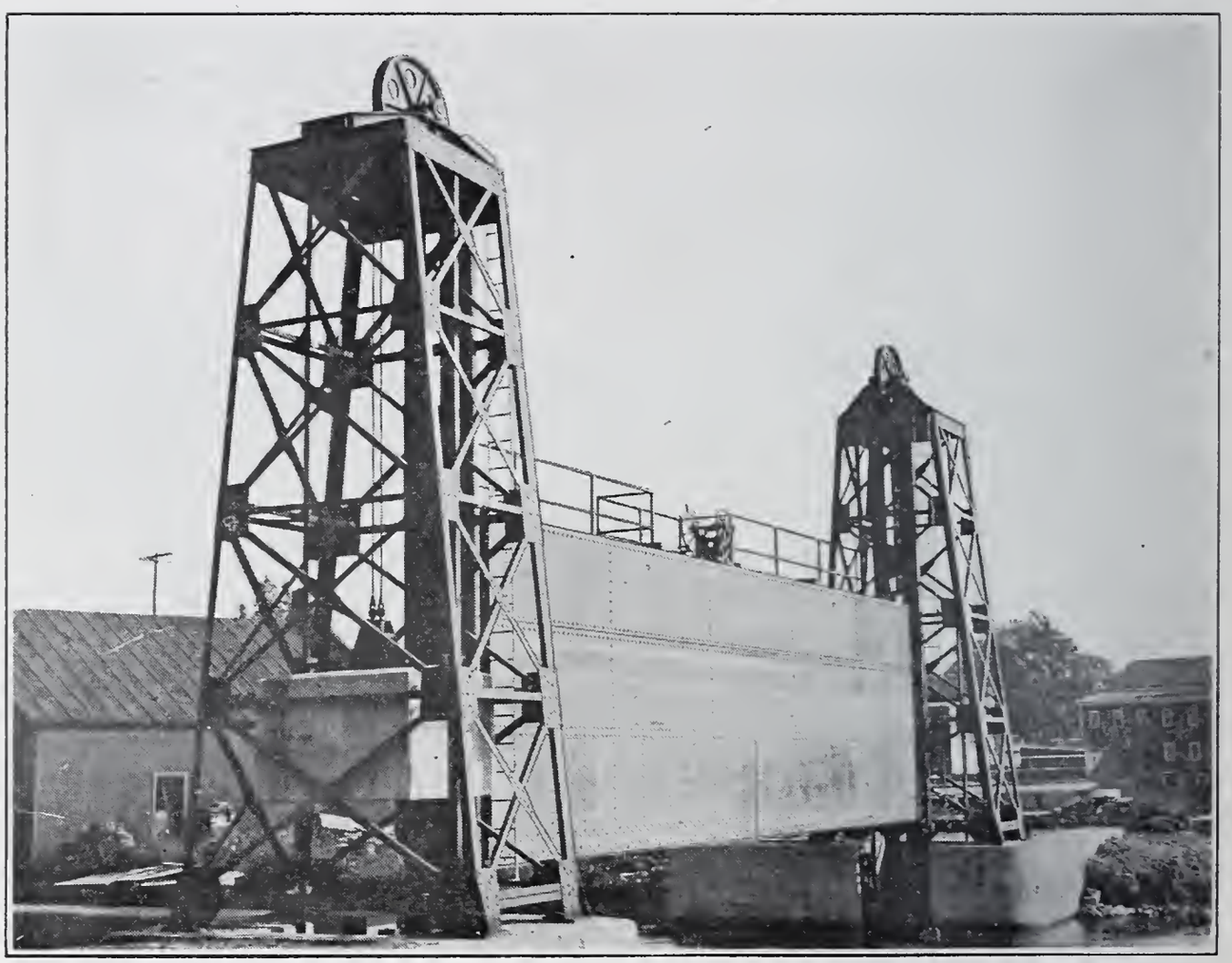

Fig. 10.—Guard gate.

At the flight of locks at Waterford a separate power plant will be built, taking water from the Mohawk River at the Crescent dam.

Siphon Spillways.—In order to reduce the fluctuations on the summit level on the Champlain Canal and at Whitehall, a form of spillway designed by Mr. G. F. Stickney, M. Am. Soc. C. E., Supervising Engineer, has been used. If the ordinary form of spillway had been used on the summit level, a crest 200 feet long would have been required. The siphon spillway, however, measures but 57 feet

between abutments and accomplishes the same results as would be secured by a longer spillway.

The structure consists of a waste weir and four siphons, the purpose of the weir section being to carry off floating debris and a certain amount of water. Each of the siphons has an area of 7¾ square feet, and acting under a head of about 10½ feet will discharge approximately 160 cubic feet per second. The inlet of the siphon is placed well below the water surface and is protected by a metal

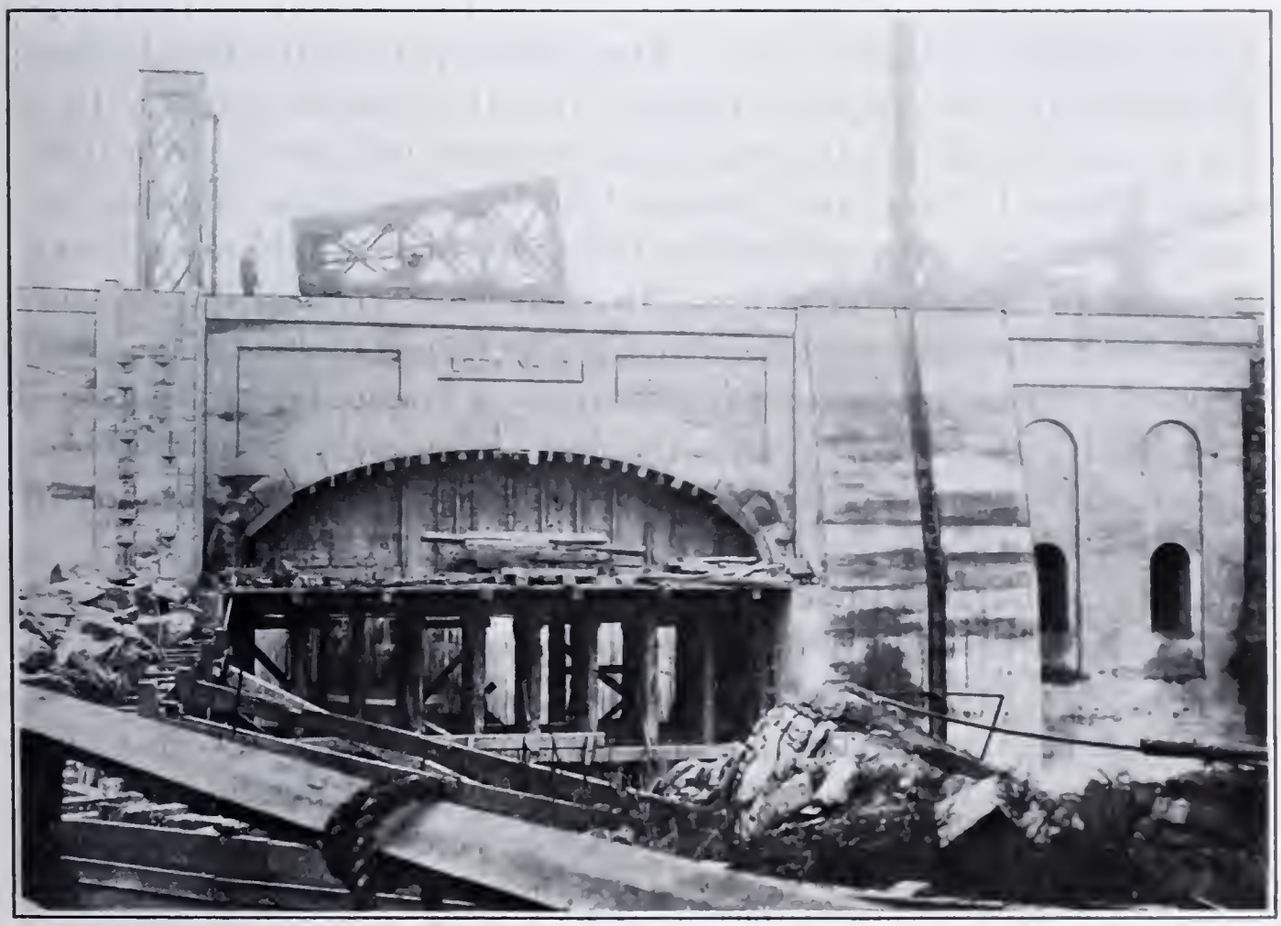

Fig. 11.—Lock No. 17.

screen to prevent the entrance of debris. To reduce the loss of head due to entry, the inlet is flared out to double the normal area.

As the siphon will not come into action until completely filled with water, it is necessary to limit the height of the crown to 1 foot, and the necessary area is obtained at that point by increasing the width. As the removal of forms at the crown of the siphon would be practically impossible, iron castings were used instead of wooden frames, and left in the masonry. Three vents, each 6 inches high by 12 inches long; pierce the wall at low-water level above the inlet of each

siphon. A little below these vents a single opening of the same size acts as a precautionary vent to break the flow in case the upper openings become clogged by freezing or otherwise. The siphons begin to discharge when the water on the open spillway reaches an elevation sufficient to fill them, and continue to discharge until the water above the spillway uncovers the vents.

The siphon spillways are completed and in successful operation.

Bridges.—Several hundred new bridges will be built over the new canal. The law authorizing the construction of the canal provides that there shall be a clearance at bridges of 15½ feet above the maximum navigable water surface. The greater part of the new bridges are therefore built as fixed bridges with the legal clearance. In a few towns and villages the local conditions are such that the construction of fixed bridges would necessitate long and steep approaches, and in other cases the approaches to fixed bridges would cause heavy damages to valuable property. In such cases vertical lift bridges, balanced with concrete counterweights by means of steel cables, will be used. These bridges always maintain a horizontal position, and are lifted sufficiently to give the legal clearance. Stairways are constructed connecting with the sidewalks of such bridges when in raised position.

It is expected that the harbor at Tonawanda will eventually become a barge canal terminal and receive lake vessels. The bridges crossing this harbor will therefore be of the bascule type, giving an unlimited overhead clearance. The movable bridges over the Oswego Canal will also be of the bascule type, and in so far as possible the new fixed bridges will be so constructed that they may readily be converted into movable bridges at some future time with small expense. All movable bridges are to be operated by electric power, which is now generally available.

All bridges of less than about 200 feet are riveted throughout. Those of longer span than 200 feet are pin-connected. Plate girders are used for a few spans at the lower ends of locks.

All bridges in cities and towns, and where there is a reasonable prospect for a future development of a large town or manufacturing center, are designed as city bridges for 20-ton road rollers and for double-track electric railways where there is a reasonable prospect of the construction of such a railway. Such bridges have floors paved with creosoted yellow pine blocks and the sidewalks are of reinforced concrete. Bridges in country districts have yellow pine plank

floors for the earlier designs and a special floor for the later designs. The special floor consists of hard maple strips about 1 inch thick by 2¾ inches or 3¾ inches wide (according to the thickness of the floor), dipped in asphalt of proper consistency and fastened together to form slabs by means of $\frac{5}{16}$-inch bolts. The slabs are spiked to wooden nailing strips on top of steel stringers. Where a good quality of maple is used, these floors give excellent satisfaction.

Contract Prices.—The following table shows the contract prices for the larger items of work under contract. This table shows rather large variations in prices bid for various classes of work. It should be remembered that the first contracts were let in 1905, and that bids have been received several times every year since that date. This covers at least one rather severe financial depression and two periods of increased cost of work.

CONTRACT PRICES.

Contract	Excavation		Embankment	Concrete			
	Nature	Price		First	Second	Third	Wash Wall
1	Dry–Wet	.57¾	.11½	7.75	6.75	5.85	1.90
2	Dry	.40	.12	6.50	5.50	4.50	1.50
2–E	....	.54	.15	.0	6.25	0	2.00
3	Dry	.41	.12	6.65	6.15	5.25	1.50
4	....	.14	.08½	0	5.20	0	2.12
5	Dry–Wet	.12⅛	.09½	0	5.65	5.25	2.35
6	Dry	.46¼	.15	0	5.25	4.90	0.80
8	....	.60	.15	0	7.00	6.00	0
9	....	.50	.17	0	6.75	6.25	2.50
10	....	.56	.15	8.00	6.40	0	2.00
11	Dry	.51	1st – .10	0	5.00	0	2.00
			2d.– .05	0	0	0	0
12	Div. 1–Wet	1.89	....	..	..	..	..
	Div. 2–Dry	.561	.165	0	7.15	0	2.75
	Div. 3–D. & W.	.308	....	0	0	0	0
	Div. 4–D. & W.	.187	....	0	0	0	0
14	Dry–Wet	.735	1st.– .17	..	..	..	..
			2d.– .11	8.00	7.50	6.50	2.50
15	Dry–Wet	.285	.175	0	6.00	0	2.25
17*	....	.96	.12	0	6.50	6.30	1.50
17	....	.96	.12	0	6.50	6.30	1.50
18	....	.52	.15	0	6.25	0	1.50
19	....	.60	....	..	..	..	..
		.17½	.14	0	8.40	0	1.35
20–A	Wet	.80	.18	0	0	0	2.40
20–B	Wet	.638	.18½	0	0	0	2.20
20–C	Wet	.51	.18	0	0	0	0
20–D	Wet	.51	.18	0	12.00	0	0
21	....	.48	.15	0	7.00	0	1.75
23	....	.28	.04	0	6.40	0	2.00

* Re-let.

CONTRACT PRICES.—(*Continued.*)

Contract	Excavation		Embankment	Concrete			
	Nature	Price		First	Second	Third	Wash Wall
24	....	..	0	0	0	0	1.80
25	D. & W.	.23	.10	0	5.75	0	1.80
26	Wet	.34¾	0	0	0	0	0
27	W. & D.	.26	.15	0	6.50	0	2.00
29	....	.22⅓	.09	0	6.50	0	2.10
30	....	.3375	.15	0	6.50	6.50	2.00
31	....	1.25	.14	0	5.90	0	0
35	W.-D. Rock	1.14½	.12½	0	7.20	0	0
37	Wet Rock	1.74	.18	0	6.50	0	2.00
38	....	.50	0	0	7.00	6.50	0
39	Wet Rock	.83	0	0	7.50	0	2.45
40	Dry–Wet	.78	.15	0	7.00	6.50	2.50
41	....	.22	.04	0	10.00	0	0
42	....	.19	.11	0	6.00	0	2.00
43	Dry–Wet	.18	.08	0	6.00	0	1.75
44	....	.20½	.08	0	6.50	0	1.85
45	Dry	.42	.15	8.00	6.75	0	2.00
46	Dry–Wet	.17	.10	0	6.25	0	0
47	Dry–Wet	.199	.15	0	6.10	0	0
49	....	.23	.15	0	5.60	0	1.75
50	....	.46	.28	0	6.00	5.00	0
53	....	.75	.15	0	6.35	0	0
54	....	.36	.18	0	6.40	0	2.50
55	....	.65	.18	0	7.00	0	2.00
60	....	.53	1st Cl .18	0	0	0	0
			2d Cl .14	0	9.00	7.80	2.50
61	....	.60	1st Cl .15	0	0	0	0
			2d Cl .12	8.00	7.50	6.00	2.50
62	Wet–Dry	.64	.21½	0	7.50	6.75	2.00
63	....	.33	(Dry) .18	0	7.00	6.00	2.50
64	....	.58	1st Cl .18	0	0	0	0
			2d Cl .14	0	9.00	7.80	2.50
66	....	.497	1st Cl .18	0	0	0	0
			2d Cl .14	0	9.00	7.80	2.50
67	....	1.45	.15	0	6.25	0	0
68	....	.75	Wet .05	0	0	0	0
68	....	Dry	.12	0	6.25	0	2.50
69	....	.85	.18	0	6.25	0	0
70	Wet	.99	.15	0	7.00	0	2.25
71	W. & D.	2.00	.15	0	7.00	0	2.50
72	....	1.24	0	0	0	0	0
73	Wet	.52	.15	0	7.00	0	2.50
		0	0				0
78	Wet	.19½	.14	0	7.00	0	2.15
79	....	1.00	0	0	8.00	0	0
27–A	W. & D.	.198*	0	0	0	0	0
		.44	.165	0	7.70	0	2.20
90	....	.45	.30	0	8.50	0	0
48	W. & D.	.48	.15	8.00	7.25	0	2.25
51	W. & D.	.47	.14	0	7.50	0	1.60
76	W. & D.	.47	.17	0	8.30	0	2.25
77	W. & D.	.38	.17	0	8.00	0	2.25
91	Dry	1.20	0	11.00	9.00	0	0

* Excavation from spoil banks.

But one unit price is paid for excavation, as there is no classification of the material excavated.

Costs.—The cost of excavation, as shown in cost data records, per cubic yard, including depreciation, interest, and overhead charges, has been as follows:

EARTH EXCAVATION.

By hydraulic dredge	from $0.05 to $0.16
By dipper dredge	" 0.13 to 0.30
By ladder dredge	" 0.15 to 0.25
By clamshell dredge	" 0.09 to 0.15
By revolving excavator and scraper bucket	" 0.05 to 0.28
By towers and scraper buckets	" 0.11 to 0.30
By steam shovel	" 0.10 to 0.40
By graders	" 0.14 to 0.30
By hand and team	" 0.14 to 0.60

ROCK EXCAVATION.

Dry rock by steam shovel	from $0.30 to $0.75
Dry rock by hand and derrick	$2.00 (average)
Wet rock	" $1.00 to $2.25

Channeling has cost from 22 cents to 38 cents per square foot, depending on the character of the rock, the rock channeled having varied from soft, badly broken shale and slate to hard limestone.

The cost for second-class concrete has been from $4.20 to $7.00 per cubic yard in place, including depreciation, interest, and overhead charges.

Organization and Direction of Work.—The organization and direction of work is in the hands jointly of the Canal Board, the Advisory Board of Consulting Engineers, the Superintendent of Public Works, and the State Engineer. It appears that the duties and powers of the Canal Board are not defined in the Constitution, but are such as may be described by statute enacted by the legislature from time to time. The law requires that this Board pass upon practically all matters in connection with the canals, including the approval of plans and estimates connected with the construction work, and all alterations to existing contracts which increase the cost of the work. It has also been the custom of the State Engineer's department to submit to the Canal Board all other alterations and changes in plan.

The Canal Board is composed of the Lieutenant-Governor, Secretary of State, Comptroller, Treasurer, Attorney-General, State Engineer and Surveyor, and the Superintendent of Public Works.

The Advisory Board of Consulting Engineers, as provided for in

the barge canal law, has passed upon the methods to be used in surveys, preparation of plans, standards of construction, and estimates, as well as upon completed plans. It is the duty of this Board to advise the State Engineer and the Superintendent of Public Works, and to follow the progress of the work, and to report thereon to the Governor from time to time. All plans and estimates for new work, as well as alterations to existing contracts, and all extra work orders are submitted to the Advisory Board for final approval. The Advisory Board must also approve all the appropriations of land, etc., in connection with this work, and in addition examines in detail and passes upon all settlements covering railroad changes.

The Superintendent of Public Works has full authority over the existing canal system, and it is his duty to maintain navigation on the old canals. The Superintendent is vested with the power to award and execute all contracts in connection with this improvement and also in making monthly and final payments to contractors; and before any alteration to a contract can be made, the Superintendent of Public Works must agree with the State Engineer to such alteration.

The barge canal law provides that no change, however small or insignificant, shall be made in the plans or specifications of any contract except by a formal alteration, approved by the State Engineer, the Superintendent of Public Works, and the Canal Board, and must be submitted to the Advisory Board of Consulting Engineers. In a work of this importance and to protect the State's interests it is also important to proceed along strictly legal lines. It is therefore often necessary to submit to the Attorney-General's department of the State government questions which arise from time to time in carrying out the work, in order that the State's legal position may be readily sustained, in case of future litigation. All this procedure often results in unavoidable delays in making changes to contracts on account of the necessary preparation and approval of formal alterations. On most large pieces of work, aside from the barge canal work, changes in plan along the line of the original contract, and incidental thereto, which are found necessary as the work develops, are made by some responsible officer. This, however, cannot be done on the barge canal work under the existing law.

The result has been a somewhat ponderous machinery, which at times has not worked as expeditiously as some of the officials involved would have wished. It has the advantage, however, of causing

a thorough examination and check to be put on each act of the State Engineer by three independent persons or bodies, thus minimizing the number of mistakes which are likely to be inadvertently made, at the same time sacrificing something of celerity.

A feature which results in a certain loss of time and of efficiency is found in the frequent changes of administration. Five State Engineers have so far had charge of this work. The personnel of the Canal Board has been completely changed four times. The office of Superintendent of Public Works has been occupied by four men during the progress of the work. The only continuing body which has had authority over the construction since its inception is found in the Advisory Board of Consulting Engineers.

Appointments of the special deputy State Engineer and the three division engineers do not come under the civil service, and have generally changed with each new State Engineer. All resident and assistant engineers, levelers, rodmen, chainmen, and office help are appointed from civil-service lists made up from the results of competitive civil-service examinations.

Progress of Work.—On March 1, 1911, contracts had been let for work on the Erie, Oswego and Champlain Canals, estimated to cost $72,710,553, comprising about 95 per cent. of the total contracts for those canals. Work of a value of $26,831,432 had been completed on that date. Two contracts were let late in 1910, amounting to $1,806,177, on the Cayuga-Seneca Canal. On January 1, 1910, 41,674,000 cubic yards of excavation and 1,140,000 cubic yards of concrete had been completed, comprising 45 per cent. of the excavation and 60 per cent. of the concrete for the entire canal.

In January, 1909, a diagram was prepared based on the "past performances" and on estimates of the probable rate of progress after that date. This diagram indicated that the barge canal should be completed early in 1915.

Since January, 1909, the monthly progress has been plotted on the diagram, and shows that the work done exceeds the amount called for by the diagram.

On many large contracts the work up to date has been in the collection of plant, and the monthly rate in the future should be greater than in the past and the work should be completed by the date named.

The following table shows the value of the contract work completed during each year from January, 1906:

Previous to January 1, 1906	$330,120
During year 1906	711,490
During year 1907	2,216,300
During year 1908	5,443,313
During year 1909	7,590,092
During year 1910	9,808,685
Total to January, 1911	$26,100,000

Probable Cost of Completed Canal.—Careful estimates, based on contracts let and to be let, show that the work on the barge canal should be completed for 2 or 3 per cent. less than the $101,000,000 appropriated for the work in 1903.

On eight contracts already completed, for which the final accounts amount to $2,045,615, the final payment was 10.6 per cent. less than the 1903 estimate, indicating that the final cost for the entire canal will show a greater saving than the 2 or 3 per cent. stated above.

It should be borne in mind that while the original 1903 plans and estimates provided for locks 28 feet wide, by subsequent action of the Canal Board all of the locks of the barge canal, either built or to be built, are 45 feet wide, thus permitting the passage of boats carrying 1800 tons in place of the 1000-ton boats which would have been accommodated by the original plan.

These changes, the lowering of the Lockport-Niagara level 5 feet, and the widening of the Lockport rock cut entail an increase of approximately $4,500,000 beyond that contemplated in the original plans and estimates. Payment of the additional amount is included in the estimates of the total cost in this paper.

Estimates of cost made in 1903 are sufficient for doing the entire work, notwithstanding the increased cost of labor and materials and the increased cost of fixed charges, such as bonds and liability insurance, now required by recent acts of the legislature.

DISCUSSION.

John Birkinbine.—The data presented by the speaker of the evening must impress upon us the facts that our sister State of New York built, many years ago, a canal system which has been jealously maintained, and that now one hundred and one million dollars is being expended to convert it into barge canals to accommodate boats of capacities suited to advanced conditions.

The maintenance of the canal system has added greatly to the material progress of the Empire State, and the array of important cities along the Erie Canal testify to the value of this improvement, for while the canal system has continued to do a large business, at least five through lines of railroad have been built to connect the Hudson River with Lake Erie.

The State of Pennsylvania expended forty million dollars (and private capital largely supplemented this) in the construction of a canal and slack-water system aggregating 1100 miles in length which has gone out of use, with the exception of the stretches along the Delaware, Lehigh, and Schuylkill Rivers, on which an important traffic is maintained, and the slack-water navigation along the Monongahela River.

Whether the improvement of the waterways of this State will be again taken up is problematical, but in view of the possibilities of such improvement the Pennsylvania Water-supply Commission approves applications for the construction of dams or bridges across important streams, with a proviso that should the State or national government in the future establish improved waterways, the dams and bridges will be altered to meet the changed conditions.

The mechanical appliances illustrated, and the item of costs presented by Mr. Landreth, demonstrate the economies of modern construction methods, and the capacity of barges which the improved canal will pass (1500 tons) admit of applying improved means of loading and discharging; for one barge will carry the equivalent of a train-load of freight.

A producer of iron ores in large quantities informed me that it was expected that when the barge canal is completed the freight on iron ore from Lake Champlain to New York harbor will not exceed 50 cents, and the charge from Lake Erie to New York will approximate the same amount.

The advantage of railway service is that material or product can be loaded as large or small units on cars at mines or industries and delivered immediately at the works or manufactories where they are to be used, whereas in water transportation the freight must be conveyed from the locality where it originates to barge or vessel, and transferred from these to the consumer, requiring a breakage of bulk. Modern methods in dock construction, loading and unloading devices, materially reduce this expense, where the volume is sufficient to utilize these satisfactorily.

In this connection it may be interesting to note the fact that 140,000 tons of sugar from Hawaii were carried to Philadelphia in 1910, using the Tehuantepec Railroad across the Mexican isthmus, the modern facilities provided at the termini of this road permitting of breaking bulk at a material saving of over all water route.

The New York barge canal and modern propelling facilities for barges are confidently expected to advance greatly the business interests of that State, and to increase the traffic between the Lakes and the ocean.

THE ATLANTIC COASTAL PROJECT.

HON. J. HAMPTON MOORE.
(Visitor.)

Address delivered April 1, 1911.

BEING neither a lawyer nor an engineer, I will not be able to speak in technical terms, but, so far as possible, will tell of the Atlantic coastal project from a practical or business point of view.

I think it is possible to make some contrasts as between the Panama Canal project and minor projects in the United States that are worthy the consideration of engineers, as they are undoubtedly worthy the consideration of business men. If I succeed in doing anything in this informal way, I hope it will be to show you that there has been not only indifference, but gross negligence, not only upon the part of the people, but perhaps on the part of the engineers, in permitting the great Atlantic seacoast, with its vast commerce, to be left in the miserable condition it is with regard to transportation.

Transportation is the life of commerce, and to it we are indebted for the development of this country. We are not prone in the United States to take very many lessons from abroad, but it would be an excellent thing for us sometimes if we did, since, notwithstanding our patriotism, to say nothing of our jingoism, we do not know quite as much from experience as do our friends of the older countries in Europe. We have made marvelous progress, but the older countries have had greater experience and have been obliged to meet problems long before those same problems reached us, and, in instances, they have settled problems in a way that would amaze us, if we were to give some heed to what they are doing. In the matter of railroad transportation we have perhaps gone beyond them, but in the matter of waterways we have not; we have not come up to their standard, and we are far behind in the matter of ports, harbors, and waterways.

The Government of the United States has not been extraordinarily generous in its treatment of the waterways; in fact, comparatively, it has been indifferent, owing largely, perhaps, to the conditions and policies of parties, for there have been differences of opinion even in regard to the railroads. Before we enjoyed many of the

latter-day conveniences, such as electric light, the telegraph, the telephone, and the railroad, people were wont to think of getting into the interior or of connecting one settlement with another by means of the watercourses—a perfectly natural means of transportation, and cheaper than overland connections. I was reading a few days ago about the state of affairs that confronted the people of western Pennsylvania at the time of the Whisky Insurrection, in 1794, when Washington was still President of the United States, and I found that those pioneers of Scotch-Irish ancestry were living upon fertile farms, and, being an industrious people, developed their resources and grew large crops of rye and other grain. Some of you may not know that Pennsylvania still grows more rye than any other State and is one of the greatest agricultural States in the Union, being perhaps fifth or sixth in rank in agricultural development. But those people were great raisers of rye, and it is recorded that they grew so much of it that they could not sell it; they fed it to their cattle and to their swine, and what was left over they turned into whisky, and out of the whisky they got money; the Government taxed the whisky, and that developed the Whisky Insurrection. Washington and all the officers of the Government were brought into that trouble, which, after it had resulted in the tarring and feathering of a great many collectors of revenue, finally led to relief measures under the law, which, after all, in most instances, is supreme. But these people, having only whisky upon which money could be raised, were obliged, because of their remoteness from industrial centers of population, to pay as much as five dollars a bushel for salt, and fifteen to twenty cents a pound for iron, or iron material for tools which came into the country, and they had to pay as much as five dollars for a hundred pounds of freight of any kind from Philadelphia. Such figures in this day would be regarded as extraordinary, and they were then. That was before the railroads.

There was no practical way of reaching that country by water, and the overland charges were too heavy to permit profitable business, consequently the people in the industrial centers along the coasts were driven to use the streams for purposes of transportation. One of the best instances I recall of the importance of the streams to the people was that which arose during the French and Indian War, when about the only fortifying done by the English was at Crown Point and Fort Ticonderoga on Lake George, with a view of stopping invasion by water. They knew they had little to fear by

land, so they turned their attention to the water. They did not expect that an army would come overland, but they did expect it to come by water, and believed that the only way it could come.

Engineers and statesmen then gradually opened up the country and developed the streams. Wherever fertile territory was unapproachable by wagon road, it was made approachable by canal. Canal engineers were developed in those days, and the tendency was all toward this kind of engineer, because of the advantages offered by canal transportation over travel by land. Along the Atlantic coast, where the population was densest, canals were built most extensively. About 1805 South Carolina was really in the fore-front of all the States in the matter of having navigable waterways and highways upon which to carry commerce. Virginia was the first State of the Union; Pennsylvania was second in rank. And, notwithstanding that Virginia has gone far behind, and New York has become the first State in the Union, Pennsylvania is still second; her condition relatively remains unchanged. She has maintained her position through the mutations of time. Pennsylvania was then quite a canal State, and is now. People got to the west by using such streams as they could, which were all marked on maps by the engineers and surveyors of those days.

Some of the old pamphlets are very interesting to men who take up the subject today. First there was the portage; and after it came the first railroad, which was a monument to the genius of Pennsylvania engineers.

Quick service, the tendency of capital to go toward the railroads, and the employment offered to new men by the railroads caused the importance of the canal to be affected, with the final result that waterways which were developed with great expense, either by the State or by the Government, were allowed to be closed up, and in some instances ruthlessly destroyed. That condition continued until about 1907, when a doubt arose in the minds of railroad managers as to the railroads being capable of carrying the business of ninety millions of people, and then a cry for increased transportation facilities was raised. The railroads of the middle west were unable to bring the produce to the east; apples, grain, fruit, and all kinds of perishable products went to waste. In the east, and especially in New England, the same thing occurred.

It is within easy recollection of many, even of those who may not have given special attention to the subject, that large consignments

of goods were laid upon railroad platforms, that complaints were rife as to delay in delivery, and that there were constant admissions on the part of the railroad men that capital could not be obtained to build sufficient equipment to keep up with the demand. This country was confronted with the fact that while it had been gridironed from one end to the other, and while it could have done a whole lot more business, erected more new factories, raised more produce on the farm, improved its waste lands, and raised greater crops, there was no use, as there was no way to get the products to market. The old means of transportation which our forefathers relied upon were no more.

Starting in the west, it was found, upon inquiry, that the people had been extremely active in obtaining Government appropriations, and, whereas they had little commerce in some instances, they had more aggressiveness than the people in the east; and it was found, too, that the western people were obtaining the bulk of the appropriations for the development of such streams as the Mississippi, and other streams where the commerce was insignificant compared with the streams of the east, which do an international trade.

It was about that time when Philadelphia began to believe that it had passed that stage where it should remain behind Baltimore and Boston in maritime importance, to say nothing of the great metropolis of New York, that an agitation was begun for an improved Delaware channel, 35 feet deep, so as to give Philadelphia a chance to exist in competition with its greater sister, New York. Philadelphia had once been a great maritime center, as it had been the capital of the nation. The Declaration of Independence and the Constitution of the United States, and the original laws, were framed here, and New York was not in the running. Philadelphia was the master of the situation. It had an outlet to New York and to Baltimore. When Pennsylvania built its railroad and got western connections, Philadelphia began to develop so rapidly that its rivals began to look on askance. New York saw the rich fields of the northwest and the traffic of the Great Lakes, and the richness of Canada along the United States border, and began to agitate for a canal connection with the great west. New York State had the natural configuration of ground to make the construction of a canal cheap, from the Lakes down the Mohawk Valley to the Hudson, and on the Hudson to the Atlantic Ocean, and while that State sought to have a canal constructed by the Federal Government, some of the other

States were wary; others again were indifferent and selfish, and the project of making the canal a Government work was abandoned. But New York finally connected the Great Lakes with the Atlantic Ocean by the Erie Canal, brought down the trade of the northwest, and Philadelphia's supremacy began to subside. The immense commerce from the northwest came down through the Erie Canal, thence down the Hudson River to New York, so naturally that New York took first place, and Philadelphia had to take second place. That is what canal construction did for the greatest city of the country.

A little over three years ago, in a movement to obtain more than local support for the improvement of the Delaware River, the idea was conceived of linking together those who were seeking support for river improvement along the coast, and those whose projects were as far behind as Philadelphia's. Such communities were induced to send representatives to a convention to look upon the map of the land as nature had left it, and resolve, if they pleased, to form a mutual understanding with themselves, to work together as one man, from Maine to Florida, to obtain for the eastern section of the country that consideration from Congress which Congress was already giving to a large degree to the middle west and the extreme west, and to assert to all the people the need for increased faci ities of transportation here, as they were clamoring for increased facilities elsewhere. The people had but to come here and be shown the map to have them raise their voice as one and say they would join in the effort. They were willing to go beyond purely local and selfish projects, what they desired for their own localities, and, by linking with others along the coast, sought to obtain something that would be of common benefit to all the people of the coast as a whole, and all the people of the country who must necessarily deal with the coast.

So the Association—the Atlantic Deeper Waterways Association—was formed, for the promotion of a continuous waterway all along the Atlantic coast, inside of its shoals and its dangerous capes, so that commerce might come and commerce might go, free of toll and safe from the danger of storm and wreckage outside. As a move in the right direction it was thought that if we could get the engineers of the country interested and the statesmen posted, linking together the opportunities that present themselves on the way, we would standardize the thing, just as the railroads are standardized

as to their tracks, and scheduled as to the time of movements of engines and of trains. And we succeeded to a large extent in arousing public interest on this great question. Parenthetically, we succeeded in securing what had not been known in this neighborhood for twenty-five years—an authorization for a 35-foot channel in the Delaware River that shall enable Philadelphia to be placed on equal terms with Baltimore and Boston, and will place it only 5 feet behind the great city of New York.

One of the results of agitation is that we succeeded in the last Rivers and Harbors Bill in obtaining not only an authorization, but an appropriation sufficient to complete a 12-foot waterway in the Delaware from Philadelphia 40 miles north to the city of Trenton. As a result of the general agitation, this much has been accomplished for the city of Philadelphia, and it remains for those who are observant to say whether or not it was wise. We proceeded to urge the linking up, not only of the lower Delaware and the now to be improved upper Delaware, but of those waterways which course through other States along the line, and which, according to the commerce that bounds upon them, ought to be developed so that we can share in that commerce as we hope to do; to take advantage of those materials and those manufactures that we may be able to make and ship to other parts of the country at a cost at least commensurate with their value. In other words, it is a question of mutual exchange. First a matter of mutual appropriation and exchange, and then a matter of mutual help and mutual advancement.

There is a vast difference in freight rates as between the wagon-road and the railroad and the waterway. The most expensive, of course, is the wagon-road. Some statisticians say that it costs 25 cents per ton-mile to carry freight by wagon-road; 7 or 8 mills to carry it by railroad; 2 to 3 mills per ton-mile on the canal, and upon the ocean much less than that. The difference, however, is so marked as to lead sometimes to the thought that it is to the advantage of existing railroads not to permit canals to be constructed, because of the tendency to affect freight rates; but, on the other hand, from the viewpoint of the shipper, if he is to do more business and create opportunities for those who come after him, he ought to have the advantage of the competition, especially if he has only one method of transportation to carry his output.

A short time ago legislative work was so far advanced that it became necessary to procure figures and data to properly report to

Congress on the advisability of proceeding with this work as a continuous project. An appropriation was obtained in 1909 of $100,000, to make a survey for a continuous route from New England to Florida, inside, and engineers were appointed by the Chief Engineer of the War Department to do this work in sections. The preliminary examinations and surveys have been made, and now there is the necessary information and data to present to Congress, upon which, later, it is hoped action will be taken.

There are waterways above Boston, and some of the rivers in the olden days were connected with Boston, which, in the Revolutionary days, was, of course, one of the largest cities of the country. Granite from Maine and New Hampshire was brought down inside, through some of those waterways. Some of the granite brought in that way was used in the building of the Custom House at Boston, and some farther south; in fact, some of it has been used in Washington. The canal scheme is indefinite north of Boston, but the Maine representatives insist that the project shall be carried north, and the engineers have been asked to survey and report on a feasible route from Boston north. The "Atlantic Coastal Project," however, starts at Boston.

Starting south from Boston, it is proposed to adopt one of three routes to Taunton River; thence to New York city; thence to Long Island Sound and New York Bay, across the State of New Jersey, and down the Delaware River to a point in the State of Delaware, where Delaware and Maryland would be bisected, and thence into the Chesapeake Bay. The Chesapeake Bay is a broad sheet of water which offers no difficulties in the way of navigation. Thence, passing on to Norfolk, through the Elizabeth River, the project proceeds south by one of two existing routes, or three, since a third has been discovered and commented upon; and passing through the Sounds of North Carolina, goes on until it comes out at Beaufort and Morehead City. Then it proceeds along the coast of South Carolina and Georgia and Florida, through some natural waterways, and through some strips of land that would still have to be cut through, until it comes to Key West.

It should be explained that the Southern Atlantic States have cooperated in this project and are in sympathy with it. It is proposed to connect with the Gulf by a canal, through the State of Florida from a point near Jacksonville, and to run along the north coast of the Gulf through natural waterways to New Orleans and the Mississippi. After that project is carried out and the north project, if capable

of development, is carried out, it will be possible to complete a circuit from Philadelphia, down the coast by way of the Gulf, up the Mississippi, along the Great Lakes, through the Erie Canal to the Hudson River to New York, and thence to Philadelphia, without in any way running the risk of the Atlantic Ocean or of the Gulf of Mexico. Small boats have made this entire trip, taking outside courses for those stretches of land where there were no inside waterways, and only recently a member of Congress told me of some boys who had undertaken to make the trip from Chicago, and had finally reached Washington by the Potomac River, and intended to proceed on their way north. I remember that at some of our conventions I have had men of a nomadic turn of mind tell me that they had made the entire trip. Some had done it in one boat, and some had used relays, but it is entirely feasible to make the journey entirely by water, although one could not make it for commercial purposes just now.

But this project does not end wholly with the Atlantic coast; nor will New York permit it to end with the Atlantic coast. The Erie Canal belongs to New York; and the State has the Hudson River, which it wants to connect with the St. Lawrence River, and so connect with the Canadian traffic. That is entirely feasible, too. Navigation is of course possible, and is a reality between New York and Troy. At this point the Erie Canal enters, and it is being improved at an enormous expense.

It is entirely feasible today for Philadelphia to secure business that goes through this great northwest canal, hitherto regarded as exclusive to this great north country. Not long ago a cargo of salt came down this inland waterway, and was delivered here much cheaper than it could have been brought by rail. Eventually it might also bring iron ore this way from the Great Lakes. The new Erie Canal will cost the State of New York $101,000,000, and the construction of this canal will be one of the great features of interest to international engineers who are to convene in Philadelphia, under the auspices of the International Navigation Congress, in June, 1912, a convention which the Mayor has been most active in promoting.

A bill was introduced in Congress at the last session, by a Congressman who has now become a Senator, for a survey that would permit the Atlantic Ocean to be connected with the Great Lakes via the St. Lawrence. There are bills in Congress now for a variety of canals; but one that is the most persistent is a project to connect Chicago with Toledo, and thus save the long voyage which the Lake steamers

now make. Of course, the saving would be tremendous if such a waterway could be devised, and since the Great Lakes are treacherous bodies of water, and life is frequently lost and much damage incurred there, it can be understood what a saving in life and property could be effected if the engineers could cut through this section of the country, which seems so favorably situated for it.

But to return to the Atlantic coastal project, the Belmont Company has taken over a project which has existed for two hundred years, and is now actually cutting a canal 8 miles long across Cape Cod. It is proposed to build a ship canal, 25 feet deep, that will save vessels making the passage outside at Martha's Vineyard and taking all the risk of the winds and the fogs which are so prevalent on that coast. That canal is now under way and much money is being spent upon it. It is known as the Belmont Canal; it is a private enterprise, and would, if constructed, charge toll. The gentlemen who are putting their money into it have taken it over with a view to making it a profitable undertaking. That is not a part of the project we are advocating along the coast, although we are in entire sympathy with it.

There have been no less than a thousand wrecks around Cape Cod during the last twenty-five years, and five hundred lives have been lost in that time. As much as fifty million tons of commerce pass Point Judith every year.

Statistics compiled by the Traffic Committee of the Atlantic Association, and supported by the statistics of the Life Saving Service of the United States, show that along the Atlantic coast there have been no less than 5,700 wrecks during the last ten years, involving a property loss in vessels and cargo of forty millions of dollars and a loss of 2,200 lives. We want to save some of that property loss; we want to save some of that cargo; we want to save some of those lives; and we want to save some of the time and the risk in that outside sailing, by letting vessels that do not want to go outside do an inside business.

The engineers of the United States, acting under the authorization of 1909, have found a safe route from Boston inside of Cape Cod; one by way of Plymouth Harbor south, and the other by way of Hingham Bay. Either of these canals would traverse fertile territory, would connect large cities that are inland, and would reach great manufacturing centers, points where large quantities of shoes and textiles are made and shipped, and which, to a large extent, are now

shipped and re-shipped, and handled and re-handled, before they can get to main lines. By the use of this canal they would get to the seaboard with much cheaper rates than are now obtained.

The first proposed canal comes along into Fall River and passes into Narragansett Bay, perhaps one of the finest bodies of water in the United States—a romantic, historic, and delightful sheet of water, surrounded by a country of great natural beauty, and where people reside whose residences are the pride of the nation. The route is from Fall River into Narragansett Bay. The next link is known as the "Rhode Island Project." The Government engineers' work was divided up according to the chief engineer's opinion of allowable distances. Colonel Abbott had charge of the Massachusetts work, and Colonel Sanford, formerly in charge of the Delaware River work, is in charge of the Rhode Island route. He has found a natural passageway inside to connect with Long Island Sound at Fisher's Island Sound, wholly within Point Judith.

The estimated cost for the Massachusetts link, from the upper point to Taunton River, for a depth of 18 feet and a width of 125 feet, is approximately, as I remember, twenty-eight million dollars, which is, if you recall, just a little more than one-half of the amount of property lost along the Atlantic coast in wreckage during the last ten years. The Rhode Island project upon which Colonel Sanford has been working is calculated to cost a little over twelve million dollars. Same depth and width. Rhode Island is co-operating with the Atlantic Deeper Waterways Association in bringing about this project. The Rhode Island people realize that it will be of the greatest importance to them to have a safeguard to life and property at this point.

During the last three days the Governor of Massachusetts has appointed a commission to estimate what the State of Massachusetts ought to do by way of co-operation with the Government to bring about the Massachusetts connection. That bespeaks progress.

The link that will connect Philadelphia with the northern project is by New York Bay, which connects with the Raritan River, and with a new route suggested by the engineers, that will bisect the State of New Jersey at a total length, I think, of 33 or 35 miles, and bring the canal into the Delaware River at a point near Bordentown. This route, suggested by Colonel Black, is estimated to cost thirty-five million dollars.

I think those three items of cost will amount to about seventy-five

million dollars; that is, about twelve million dollars more for a waterway through the most productive manufacturing district in the country—twelve million dollars more than President Taft, along with Congress, has approved to be spent upon the Ohio River to obtain a 9-foot depth from Pittsburg to Cairo. When I said to you in the beginning of this talk that I thought I could show you there had been a neglect of the streams along the Atlantic seaboard, I meant exactly what I said. There is more tonnage in this little link behind Staten Island, over a length of 16 miles, more commerce—four times over—than upon the whole of the Mississippi and all its tributaries thrown in, with the single exception of the Ohio River. And below the city of Philadelphia there is seven times the commerce there is on the Mississippi, leaving out the Ohio, which derives most of its business from western Pennsylvania. And yet upon the Mississippi there has already been spent upward of two hundred millions of dollars, and what has been accomplished? Every one knows what has been accomplished, or rather what has not. Compare this with the twelve or thirteen million dollars spent upon the Delaware; we are to get ten million dollars for a 35-foot channel in the Delaware, compared with two hundred millions for the Mississippi to obtain a depth of 6 feet on the upper reaches and 9 feet on the lower reaches. Think of it! So I say to you we have been neglecting the streams on the Atlantic seaboard, and when we propose a project that will save forty millions of dollars and save thousands of lives, we want the support of men like you. Think of two hundred million dollars spent on a project like that of the west, when these lives and this commerce could have been saved if the eastern people had only been more wide-awake. If we have not done this, then I say we have been neglecting our opportunities, and you as engineers have not been doing the work that ought to have been done by you and men of your class.

In opening up these canals, the argument is that we would not only bring cities together and lead them into an interchange of their commerce, and do a straight business with each other, and find greater outlet for their goods, but we would also build up communities along the coast; and if we were to open up a suitable canal from Philadelphia to New York, and make it free, and take it away from private control and the ban of tolls, industries would grow up along the line of that canal, and those industries would thrive, and New York and Philadelphia would be effectively linked together. It is not a

dream, because New York is even now obliged to reach out for more room, and we are building north.

Coming on down through Philadelphia by the Delaware River, we pass to the Chesapeake and Delaware Canal, which is 13⅝ miles long. It was started in 1825 and finished in four years. It was built in the old-fashioned way, not with the wonderful steam shovels used on the Panama Canal. It was difficult work, but the Government saw a means of connecting the Delaware River with Chesapeake Bay, and it contributed largely toward that project, as did the State of Pennsylvania and the State of New Jersey. It is a private project today, and it ought not to be. The cost of that canal is insignificant compared with the amount of business that is done upon it, or could be done upon it if it were under Government control.

Why is that canal so important? Philadelphia is 90 miles from Baltimore by rail; it is 120 via the Delaware River and this canal and Chesapeake Bay and the river leading to Baltimore—the Patapsco. Before the canal was built, the only waterway to Baltimore from Philadelphia was this outside way. Now look at it and see the wisdom of making that short link of 13 miles. From Philadelphia, down the Bay, outside to Cape Henlopen, down to Cape Charles, Norfolk, through Hampton Roads and up the Chesapeake Bay to Baltimore is 325 miles. If a man wants to sail outside today, that is what he has to do to get to Baltimore: he has to make that long run, take all the risk of fogs, shoals, winds, pay the increased rates for maintenance, insurance, etc., whereas this little cut of 13.5 miles enables trade to pass through in safe courses from the north to the south, saving almost this entire distance of 325 miles outside. A company now sends its boats through the Chesapeake and Delaware Canal from Philadelphia to Baltimore. The rates which this company charges are not much less than the railroad rates, and it would almost pay a man to take that outside course, if he wanted to save money in the matter of freight rates.

But the point is, a transportation company uses this canal and does business with the two cities. A great deal of material passes through this canal; all kinds of large, heavy material, fertilizer, bricks, and lumber. The transportation company pays 25 per cent. upon its gross receipts for the privilege of going through that canal, which is a pretty heavy handicap. That 25 per cent. is more than equivalent to railroad rates, and you can see the disadvantage of having a canal of that kind under private control.

We ought to take over that canal, rebuild it, or build a new one, and the cost would not be more than eleven or twelve million dollars at the outside. It is said that between Philadelphia and Baltimore the amount of tonnage that takes to the water is somewhere between fifty and seventy-five million tons. Twelve million dollars would build a canal that would save that tonnage all outside risk.

The entrance to the Chesapeake and Delaware Canal has a depth of 9 feet of water. New York State is constructing a 12-foot barge canal, and is going to pay one hundred and one million dollars for it, which is more than is needed for the entire waterway from Boston to Key West.

The project continues from the lower Chesapeake south from Norfolk. There are two canals now between Norfolk and the two Carolina sounds. The Dismal Swamp Canal is one of great historic interest. Washington himself surveyed this country, and was very much interested in the canal. He found that Lake Drummond was a stream fed not only from some mysterious source, but so perpetually fed that it would be of great benefit to these great bodies of water in North Carolina. These two sounds, the Albemarle and the Pamlico, the one fresh and the other brackish, are the two largest bodies of fresh and brackish water in the United States, outside of the Great Lakes, and have 2500 miles of navigable waterways feeding them. The entire coastal country here is very largely in the primeval state that it was in the days of Washington. The construction of canals would undoubtedly help this part of the country. Much of this useless land would be drained by the canals and made useful; this country would grow, when relieved of the overplus of water and marsh which frequently prevails. At the lower end of Pamlico Sound is an entrance to the ocean.

I want to call your attention, however, to Cape Hatteras, which is regarded by many as the most dangerous point along the coast, to the mariner. The strips of beach here protect the mainland, and these inland waterways which it is proposed to develop are much like those which New Jersey has begun to develop.

The Chesapeake and Albemarle Canals are both toll canals, and during the last nine months of 1910 they carried more than 7200 vessels of one kind or another from points south to the north, and from Norfolk, south.

Congressman Small some years ago tried to have a channel cut through the lower end of Pamlico Sound to enable vessels to get to

or from the ocean, and avoid Cape Hatteras. There was no outlet for either of these two sounds fed by rivers, 2500 miles in aggregate length, except a few shifting inlets and a little stream known as Core Creek, which would not safely accommodate any vessel drawing more than 4 or 5 feet of water. The Small project was to get out through Adams Creek, and to go safely on to sea, or to come safely in from sea and obtain the shelter of the inside course.

Five hundred thousand dollars was authorized for that canal; but it was not spent on it; it was completed for less than that amount, and opened last January, two years after the work was started. When I was there in January, I saw new buildings along that canal that had not existed when I was there before. I saw attempts at new settlements in that wild country, and I met men who had never seen a city, and were only then beginning to understand what it was to meet people and to exchange money. I saw land made salable and worth cultivating. During the first month after that canal was opened over 300 vessels of one kind or another did business upon its banks or carried freight through it. Most of them were vessels the farmers or woodsmen had acquired in order to get from their homes to market.

It is proposed to pass from the last mentioned point, across to Cape Fear River (that is a matter now under consideration, and is being taken care of by the congressman at that point), and then simply along the coast line down along Georgia and into Florida. The way here is almost provided, and the depth of water is fully sufficient to accommodate such vessels as would have to pass through.

The line along the Florida coast down to Key West is open now for small boats, passing from St. Augustine to Key West, inside, or running up to Jacksonville, and it is even possible, in a small motor boat drawing not more than 4 or 5 feet, to pass all the way down.

Now I will close with this thought: We spend a great deal of money on the various departments of the Government of the United States, and that money must come from some source or other. I have studied the question of our resources, and believe that most of our money is derived primarily from the soil, and then from the material that man is able to make from the products of the soil combined with those God-given qualities that are presented to him. In other words, the agriculturalist and the manufacturer and the miner are the real wealth-producers of the land, and while the agriculturalists may not be in such close touch with the engineer in all lines as the manu-

facturer is, he nevertheless is dependent upon him for certain articles of machinery and certain improvements; in the invention of modern machinery for the saving of labor, and many other things, just as the Government is dependent upon him for great constructive works that are to be done in the name of the Government.

I would like to see a little more of the practical engineer in our United States life, for the engineer is a creative force, and our national life would be benefited in every way by his activity.

Considering the congestion in large cities and the tendency to overdo the professions, I have wondered whether it would not be well for this country to encourage more construction learning, rather than the literary, or the purely artistic, or many other branches which may not be so important after all; would it not be better to encourage the useful rather than the ambitious side of life? In other words, it seems to me that if the Government is to raise the money from the agriculturalist and the worker, and if the Government is competent to spend the money thus acquired, it should also consider the social welfare of its people by spending a little money encouraging the practice of constructive work through the youth of the country. It would thus be making two blades of grass grow where one grew before.

All over the west we find greater activity than we do here in the east; more aggressiveness than here. The western man has had to hew his way through the wilderness, and the western dweller is becoming more and more, day by day, the competitor of the east and a bidder for the industrials of the east. He comes in for appropriations, and he gets them. He applies them to industries and manufactures. Indeed, he is forging ahead. A short time ago Boston thought it was the greatest center of the shoe industry in the United States, but the last census showed that not only had St. Louis exceeded Boston in population, but it had also become, way out there on the Mississippi, in the interior of the country, the first and greatest shoe manufacturing city of the United States. But the western man is moving, and on the hustle, and in Seattle, with perhaps only one-fourth or one-fifth the population of Philadelphia, they have seven or eight lines of railroad coming and going, and all the capital incident to construction for use in that community, while Boston jogs along with one railroad system and is entirely satisfied that it is moving along with the rest of the world.

In Philadelphia, with one of the most magnificent rivers of this

country, the people have been satisfied with conditions as they were, leaving the river at a depth of 24 or 26 feet, until all the large cities along the Atlantic seaboard had deeper channels, and until many of the cities of the middle west had risen and grown upon the capital sent from here, rather than applying it to our own enterprises and upbuilding industries in our own community. Men leave Philadelphia, and New York, and Boston, and travel at great expense and much inconvenience to Montana, and Idaho, and Washington, and Oregon, to buy land at hundreds and sometimes thousands of dollars an acre, when they could buy it within twenty miles of Philadelphia for from fifty to a hundred dollars an acre and make it equally productive if they would only stick to it. And I have been thinking that if we were to open up a little in the east and become broader in our views, and link up new territory that would appeal to the agriculturalist and the industrialist, he would be encouraged to go into our own neighboring country that is now lying practically waste. I believe if we were to spend a little money opening up these waterways, we would be doing one of the best things for ourselves, and one of the best things that we could do for the uplift of the nation. We would at least afford an opportunity for wholesome and profitable employment, not only to engineers and the ambitious and worthy youth of the country, but to that unsettled portion of our population that seems to hang wholly upon the coattails of prosperous men.

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, April 1, 1911.—The meeting was called to order by President Christie at 8.30 p. m., with 116 members and visitors in attendance. The minutes of the Regular Meeting of March 18th were approved as printed in abstract. The amendments to the By-Laws, relative to the status of the Junior Section, proposed at the meeting of the Club on March 4th, were brought up, and, after discussion, were approved for letter ballot.

Following a report of the Tellers, the President declared the following elected to membership: Active, George A. Baker, Alfred D. Morris, John Wallace Thompson, Charles D. Watson; Junior, Charles Emil Hubsch, John Allen Remon, Victor Shuman.

Mr. J. Hampton Moore, visitor, presented the paper of the evening, entitled, "The Atlantic Coastal Project," which was discussed by Col. J. C. Sanford, A. B. Burke, John C. Trautwine, Jr., James Christie, and others. On motion of Mr. Swaab, the thanks of the Club were extended to Mr. Moore for his interesting paper.

Business Meeting, April 15, 1911.—The meeting was called to order by President Christie at 8.30 p. m., with 72 members and visitors in attendance. The minutes of the Business Meeting of April 1st were approved as printed in abstract.

The Tellers of election presented the following report of votes cast on the amendments to the By-Laws affecting the Junior Section: For the amendment, 63; against the amendment, 0. The President, in accordance with this report, declared the By-Laws so amended.

Mr. William B. Landreth, visitor, presented the paper of the evening, entitled, "The New York State Barge Canal," which was discussed by James Christie, John Birkinbine, and John C. Trautwine, Jr.

Business Meeting, May 6, 1911.—The meeting was called to order by President Christie at 8.30 p. m., with 112 members and visitors in attendance. The minutes of the Business Meeting of April 15th were approved as printed in abstract.

A Committee of the Board, formed to draft a resolution on Building Laws in this State, presented its report, on which it was desired to obtain the sense of the meeting; but, after discussion, it was ordered that the matter be laid upon the table.

Following a report of the Tellers, the President declared the following elected to membership: Associate, Charles J. Corr; Junior, Francis X. Kern, Jr., Henry P. Kirchner, and James Logan.

Mr. Frederick W. Taylor, visitor, presented the paper of the evening, entitled "The Principles of Scientific Management," which was discussed by John C. Parker, H. M. Chance, E. M. Nichols and other members and visitors. President Christie expressed to Mr. Taylor the thanks of the Club for his most interesting paper.

Regular Meeting, May 20, 1911.—The meeting was called to order by President Christie at 8.40 p. m., with 78 members and visitors in attendance. The minutes of the Business Meeting of May 6th were approved as printed in abstract.

Owing to business engagements, the speaker of the evening, Mr. Spencer Miller, was unable to be present, and, in place of his paper on the cableway, Mr. Henry H. Quimby, active member, presented a paper on the Forty-second Street Bridge in Philadelphia, which was discussed by S. M. Swaab, L. F. Rondinella, John C. Trautwine, Jr., Carl Hering, Wm. Easby, Jr., Robert Schmitz, and others.

Business Meeting, June 3, 1911.—The meeting was called to order by President Christie at 8.30 p. m., with 79 members and visitors in attendance. The minutes of the Regular Meeting of May 20th were approved as printed in abstract.

The President announced that the following members had been elected to serve as Committee on Nominations for the coming year: Wm. Easby, Jr., Chairman, H. H. Quimby, Joseph C. Wagner, W. B. Riegner, Herbert Rice, H. E. Ehlers, and William C. Kerr.

Following the report of the Tellers, the President declared the following elected: Active, Moses C. Craig, Walter C. Kennedy, Robert W. Shelmire, Edgar Stilley, Eddy Russell Whitney; Junior, William Louis Clayton.

This meeting was a joint meeting of the Engineers' Club and of the Local Section of the American Society of Mechanical Engineers, whose Chairman, Mr. Thomas C. McBride, presided during the reading of the paper.

Mr. S. B. Flagg, visitor, presented the paper of the evening, entitled "The United States Fuel Testing Plant," which was discussed by S. M. Swaab, James Christie, John C. Parker, Thomas C. McBride, and others.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Regular Meeting, April 13, 1911.—Present: President Christie, Vice-Presidents Hess, Hewitt, and Plack, Directors Hutchinson, Swaab, Halstead, Worley, Cooke, Develin, Gilpin, Vogleson, the Secretary, and the Treasurer. The minutes of the Regular Meeting of March 16th were read and approved.

The Secretary presented the monthly statement of the financial condition of the Club, which showed a net gain for three months of $312.19.

After a discussion of delinquent accounts, it was ordered that for house charges of less than $1.00, a member's credit should not be stopped, nor should his name be posted on the bulletin board.

The death of Mr. Heber S. Thompson, which occurred on March 9, 1911, was announced.

Following the reading of a letter from the Philadelphia Chapter of the American Institute of Architects, it was ordered that a letter be written to His Honor, the Mayor, indicating the indorsement of the Engineers' Club of the development of a comprehensive city plan, and recommending the appointment of a permanent commission on city planning.

Following a letter read from the President of State College, it was ordered that the President appoint a delegate from this Club to serve as elector at the State College Annual Meeting.

On motion, it was ordered that the House Committee be authorized to make arrangements for a visit to the Engineers' Club of Brooklyn, provided the same be done without expense to the Club.

Following the reading of a report from the Committee on Standardization of Engineering Elements, it was ordered that this Committee be made a permanent Committee of the Board of Directors, and that it be authorized to appoint the two sub-committees recommended in its report.

For the guidance of the House Committee, it was moved that the sense of the Board was that the rent of the meeting-room for outside organizations be fixed until September 1, 1911, at $10.00, with an additional charge of $3.00 for the use of the lantern.

Regular Meeting, May 18, 1911.—President: President Christie, Vice-Presidents Hess and Plack, Directors Hutchinson, Mebus, Swaab, Halstead, Worley, Develin, Gilpin, Vogleson, the Secretary, and the Treasurer. The minutes of the Regular Meeting of April 13th were read and approved.

The Secretary presented the monthly statement of the financial condition of the Club, which showed a net gain for four months of $555.44.

The letter to the Mayor of Philadelphia, indicating the indorsement of the Engineers' Club of Philadelphia on the development of a comprehensive city plan, ordered to be sent at the last meeting of the Board, was read.

It was ordered that the $850.00 appropriated as a sinking fund for retiring

the building notes be made immediately available, if necessary, and that other money be applied from the general funds to make necessary payments and interest charges on the building fund notes.

It was ordered that the President and Treasurer be authorized to negotiate a loan of $1000 for thirty days, if necessary.

The following four Junior members were transferred to the Associate grade: Keith F. Adamson, C. A. Bockius, John S. Green, and Thomas S. Martin, Jr.

The following resignations were read and accepted: George A. Buvinger, John A. Boers, and Bernard T. Converse, active members.

A letter from Mr. John G. Hendrie, requesting transfer to non-resident membership, was read, but no action was taken.

Mr. Charles F. Mebus was appointed delegate of the Club to attend the election of Trustees at Pennsylvania State College on June 13, 1911.

The following were elected as Committee on Nominations: Wm. Easby, Jr., Chairman, H. H. Quimby, Joseph C. Wagner, William C. Kerr, W. B. Riegner, Herbert Rice, and H. E. Ehlers.

It was ordered that the Secretary notify those members of the Board of Directors who had not been attending meetings of the Board, calling their attention to the clause in the By-Laws governing such absences.

On motion of Mr. Hutchinson, the following resolution was passed:

Resolved: That a committee of three members of the Board of Directors be appointed by the President to consider the matters of smoking in the meeting room during the sessions of the Club, and of smoking in the board-room during the meetings of the Directors, and to report the results of its deliberations, with its recommendations, to a meeting of the Board, as soon as practicable.

The resolution prepared by the special committee of the Board, in regard to indorsement of new building laws in Pennsylvania, was read, and it was ordered that the Secretary send a copy of this resolution to the Governor of Pennsylvania.

Adjourned Meeting, June 15, 1911.—Present: President Christie, Vice-Presidents Hewitt and Plack, Directors Mebus, Swaab, Wood, Halstead, Worley, Cooke, Develin, Gilpin, Vogleson, the Secretary, and the Treasurer.

The Secretary presented a report of the financial condition of the Club, which showed a net gain of $875.28 for the first five months of 1911.

On motion of the Secretary, the additional sum of $940.00 was transferred to the building fund account, to pay interest on members' notes, and to take up all outstanding obligations.

A list of delinquent accounts was read and was referred to the Treasurer, with power to act in each case according to his discretion.

The resignations of Keith F. Adamson, L. F. Rondinella, R. S. Riley, and H. N. Twells were read and accepted.

Mr. Thomas S. Martin, Jr., was, upon request, transferred from Associate to Active membership.

A letter from the Engineers' Club of St. Louis, requesting that a letter be sent to President Taft, indorsing certain modifications in the patent laws, was read and laid upon the table.

The President announced the following as members of the special committee

to consider the question of smoking in the meeting-room: Henry Hess (Chairman), F. K. Worley, W. P. Taylor, Richard Gilpin, and W. L. Plack.

It was announced that the following had accepted service on the Committee on Nominations for the current year: Wm. Easby, Jr. (Chairman), H. H. Quimby, J. C. Wagner, W. B. Riegner, Herbert Rice, H. E. Ehlers, and Wm. C. Kerr.

The meeting adjourned, upon motion, at 9.30 P. M., to continue on call of the chair.

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXVIII. OCTOBER, 1911. No. 4

PAPER NO. 1101.

NOTES ON THE DESIGN OF IMPELLERS OF MODERN CENTRIFUGAL PUMPS.

N. W. AKIMOFF.

(Active Member.)

Read March 4, 1911.

THE impeller shown in Fig. 1 is characteristic of an ordinary centrifugal pump for high lifts and moderate capacities. In such pumps the ratio D : d is considerable, about 2 : 1 to 3 : 1, and the layout of the vanes of such an impeller does not present any special difficulties.

Fig. 2 shows a typical low-lift impeller; the ratio of the outside diameter to the diameter of inlet is here reduced to a minimum; this may be due to the low head required or else to a high rotative speed.

The layout of the vanes of such an impeller is a problem of a rather special nature, and admits, by proper treatment, of a definite solution. To undercut the inlet tips of the vanes as shown by *a* would result in too short a vane (radially). To shape the inlet tips as shown in *b* and *c* would mean nothing at all, and only the poorest result can be expected from such an arbitrary outline. The correct shape is *d*, and the object of this paper is precisely the layout of this curve—the *entrance curve;* also of the inlet tips of the vanes thereby outlined.

The side view of such an impeller is given in Fig. 3, where two blades are shown; such blades are necessarily of the doubly curved kind, unlike the blades of Fig. 1, which are of cylindrical nature.

Before taking up the layout of the blades proper it will be necessary to look into the nature of the flow of water into the impeller (or, rather, through the impeller). This problem has been treated by Dr. Prasil in his "Mouvement des liquides dans les corps creux de Révolution" (Grenoble, 1908).

His method is as follows: A jet of water impinging on a plane can be treated mathematically by applying the general equations of hydrodynamics. We first assume that the movement is of a

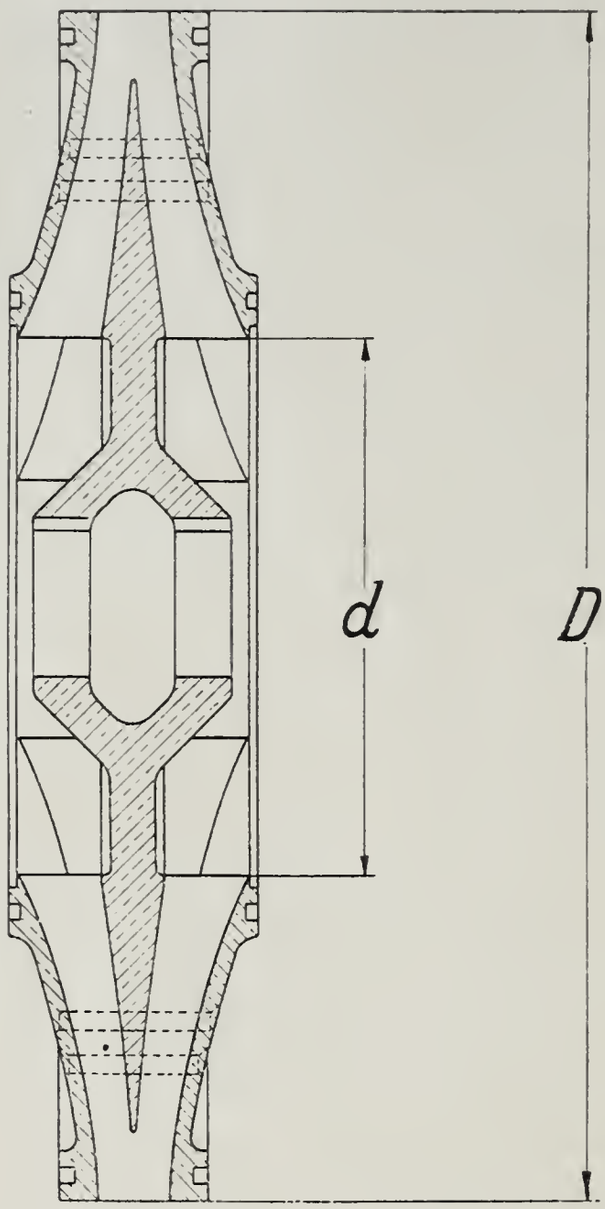

Fig. 1.

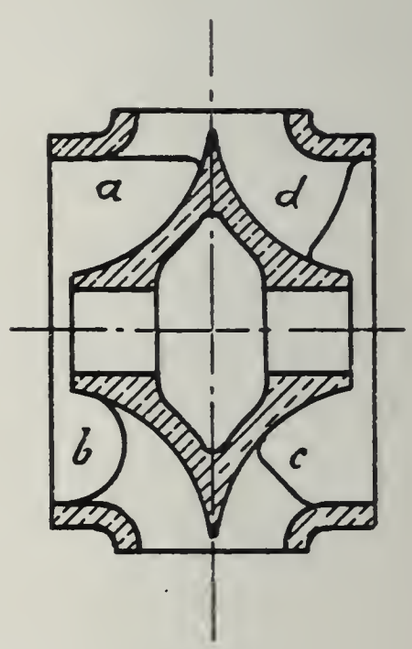

Fig. 2.

steady, non-vortex nature; we further simplify the general equations by using cylindrical coördinates, z, r, and the general equation thus obtained becomes

$$\frac{\delta^2 F}{\delta z^2}+\frac{1}{r}\frac{\delta F}{\delta r}+\frac{\delta^2 F}{\delta r^2}=O\,..(1)$$

where δ denotes partial differentiation, z and r are axes shown in Fig.

4, and F is the *velocity-potential, i. e.*, a function whose derivative as to z is the velocity along z, and whose derivative as to r gives the velocity along r.

One of the integrals satisfying equation 1 is

$$F = 2kz^2 - kr^2 \ldots (2)$$

where k is a constant. It is easy enough to see that

$$\frac{\delta^2 F}{\delta z^2} = 4k; \quad \frac{\delta F}{\delta r} = -2kr \text{ and } \frac{\delta^2 F}{\delta r^2} = -2k; \text{ whence } 4k - 2k - 2k = o$$

so that F (equation 2) is a solution of equation 1.

The equation

$$F = const \ldots (3)$$

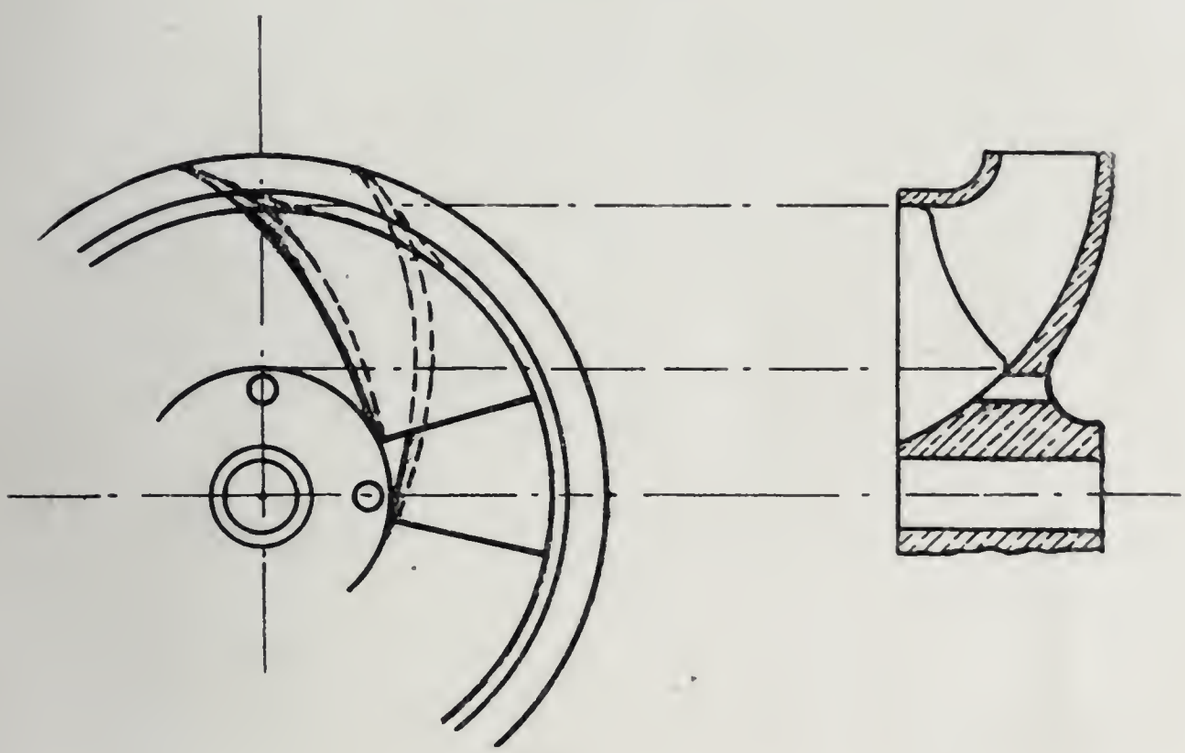

Fig. 3.

gives the curves of constant velocity-potential; this equation can be reduced to the well-known form

$$\frac{z^2}{a^2} - \frac{r^2}{b^2} = 1; \text{ where } a = \sqrt{\frac{c}{2k}} \text{ and } b = \sqrt{\frac{c}{k}} \text{ (} c \text{ being the constant from (3))}$$

This is an equation of a family of hyperbolæ the asymptote of which forms with the z axis an angle whose tangent $= \frac{b}{a} = \sqrt{2}$, so that the angle is 54° 44′.

The velocity along z is

$$w = \frac{\delta F}{\delta z} = 4kz \ldots (4)$$

and the velocity along r is

$$v = \frac{\delta F}{\delta r} = -2kr \,..(5)$$

so that w is independent of r and v is independent of z (and this is precisely the reason why (2) is the solution of our problem). The total velocity of each particle of water is then

$$c^2 = w^2 + v^2 = 16k^2\, z^2 + 4k^2\, r^2 \,..(6),$$

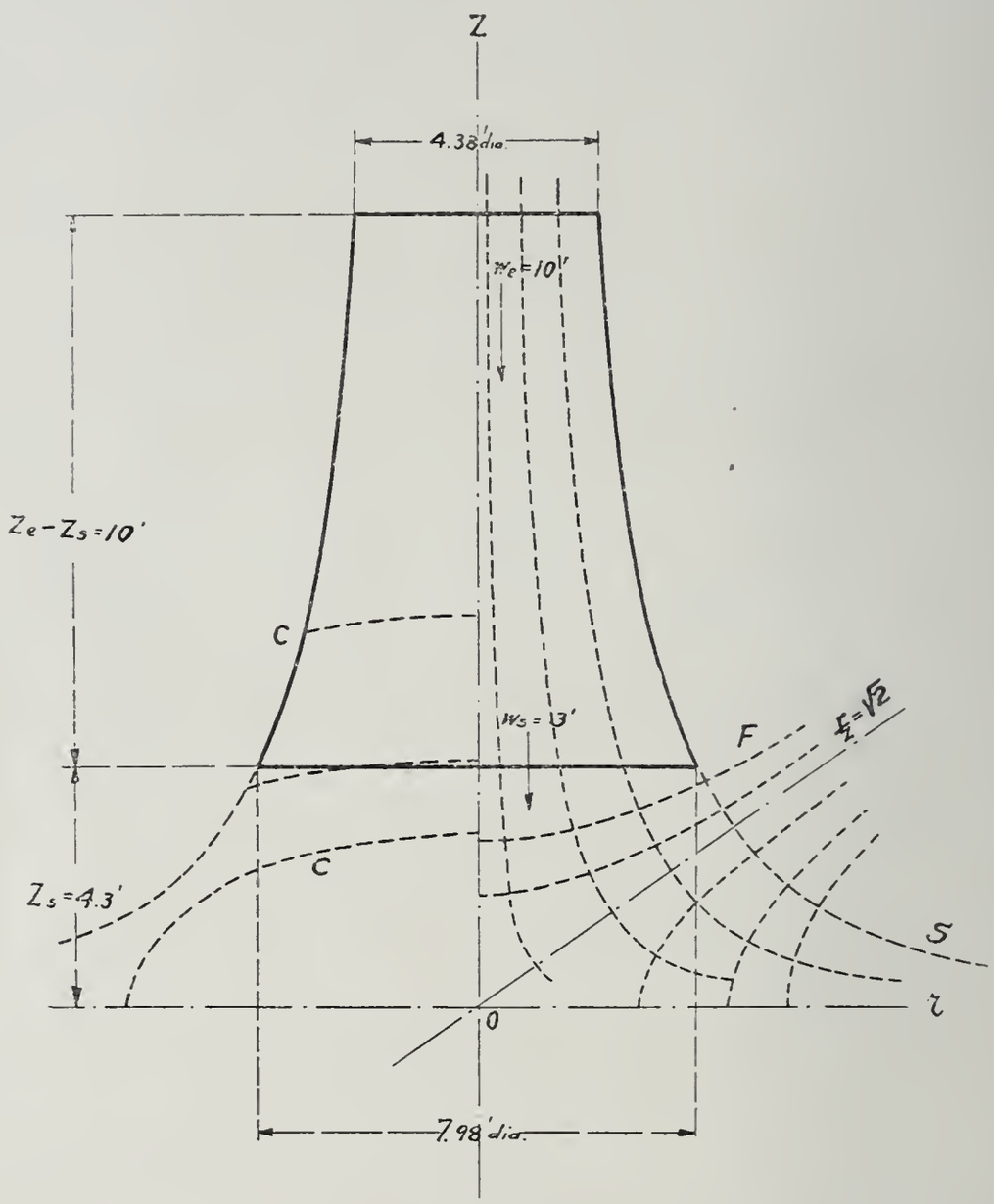

FIG. 4.

which is an equation of an ellipse whose axes are 2 : 1, and whose smaller axis is along z; the equation of the stream lines will be, of course,

$$\frac{dr}{\frac{\delta F}{\delta r}} = \frac{dz}{\frac{\delta F}{\delta z}}; \text{ so that } \frac{dr}{-2kr} = \frac{dz}{4kz}$$

integration gives $S = r^2 z = \text{const.}$ (See Tait, "Dynamics," p. 323, or Forsyth, "Diff. Eqns.," p. 131, on Trajectories.) These are curves of third degree, having the axes z and r for asymptotes. Fig. 4 also shows c lines (of equal total velocity) as well as F lines (equal velocity-potential) and S lines (stream lines or lines of flow). This layout was made for the following data: w_e at top = 10 ft. per second; w_s at bottom = 3 ft. per second. The total length of sleeve $z_e - z_s = 10$ ft. Discharge per second = 150 cu. ft.

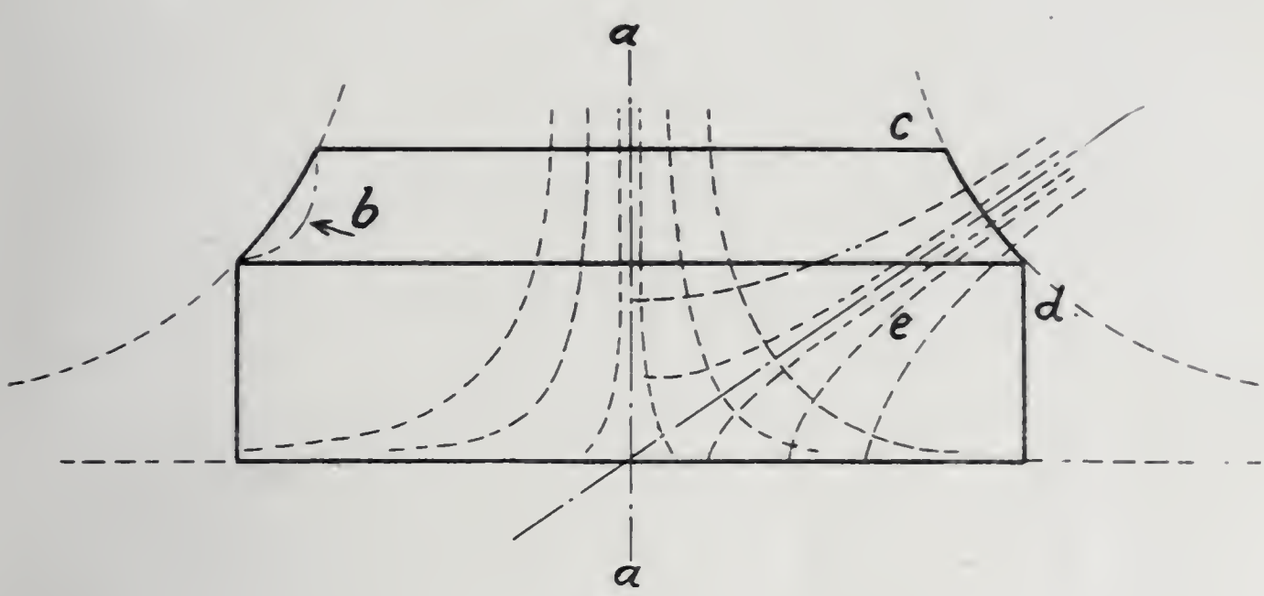

Fig. 5.

In order to determine F we first find k as follows: From (4) we have $w_e = 4kz_e$ and $w_s = 4kz_s$, so that $w_e - w_s = 4k\,(z_e - z_s)$; now, $w_e = -10$ and $w_s = -3$ (the sign — shows flow *toward* the origin); or $-10-(-3) = 40k$; hence $k = -\frac{7}{40}$, so that from (2)

$$F = \frac{7}{20} z^2 + \frac{7}{40} r^2 \text{ and } w = -\frac{7}{10} z \text{ and } v = \frac{7}{20} r, \text{ whence } c^2 = \frac{49}{100} z^2 + \frac{49}{400} r^2.$$

F and c lines can easily be plotted by assigning various values for F and c and determining z and r from corresponding equations.

$$\text{From } w_e = -\frac{7}{10} z_e \text{ we have } z_e = -\frac{10}{7} w_e = \frac{100}{7} = 14\tfrac{2}{7}$$

Knowing the amount of water handled per second, we have $r_e = 2.19$ ft., so that the outer stream line will be given by the equation $S = r^2 z = 68.5$; other lines of flow will be found by assigning smaller values for S.

It is a most helpful exercise indeed to work out a few examples for some known conditions. Fig. 5 represents a similar layout for a

different set of conditions, roughly approaching an outline of a single suction impeller of a centrifugal pump. From it we may observe the following: For a free, non-constrained flow the entrance, *c*, cannot be quite parallel to the shaft; neither can the discharge, *d*, be exactly at right angles to the shaft. The entrance curve, in order to be ⊥ to the stream lines, must be of some such shape as *e*.

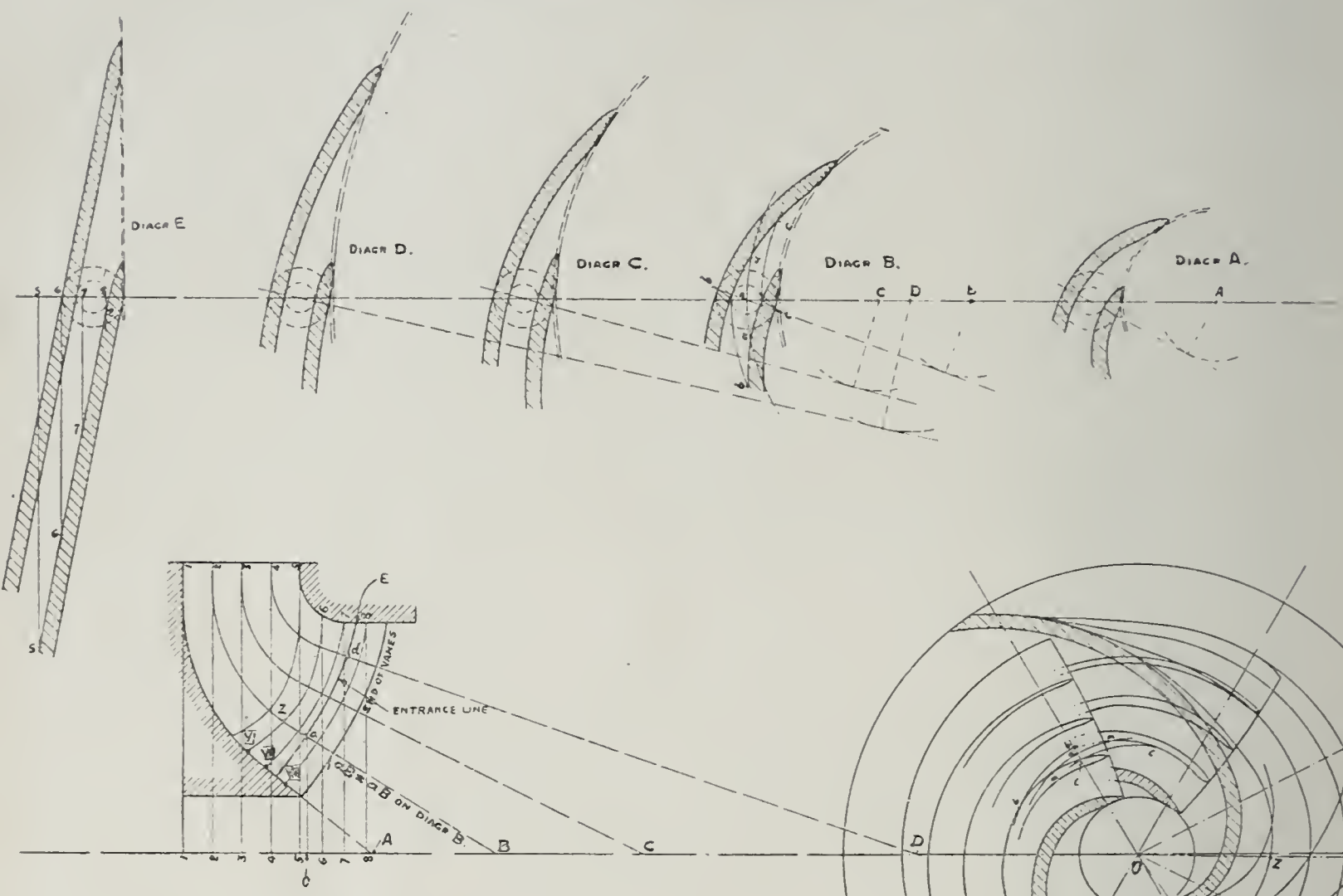

Fig. 6.

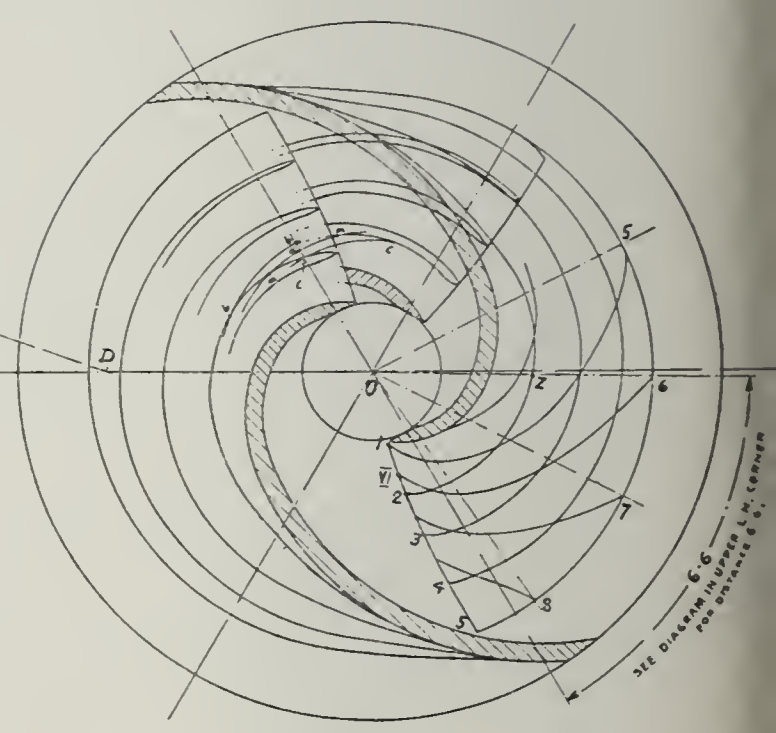

Fig. 7

In practice, however, we deliberately depart from these conditions in some such manner as shown at *b*, and, by so doing, alter the velocities of outer streams. It can be shown that for such conditions of flow the velocity will be inversely proportional to the radius of curvature of each stream. In working out an actual impeller layout it is of great importance to know what the theoretic stream lines would be

and how far we depart from them, so that new stream lines can approximately be drawn corresponding to the distorted shape of the profile.

The actual layout is done in the following manner: Being given the capacity, the total head and the speed of the pump, we first determine the diameter and the width of the impeller, using existing theories and practical data. (See our article in the "Journal of the Franklin Institute," May, 1911.) We now draw the stream lines (Fig. 6), such as 1–*A*, 2–*B*, 3–*C*, and 4–*D*. The entrance line is then laid out subject to two conditions: (*a*) It is at right angles to each stream line at intersection; (*b*) its *length* is such that it will admit water into the impeller at the same velocity as the velocity of suction. This suction velocity, prescribed beforehand, is constant, while the peripheral velocity is, of course, proportional to the radius, so that the triangle of velocities for *d* will be quite different from that for *a*. The next step is then to determine the vane angles corresponding to various points of the entrance curve, such as *a*, *d*, etc., using the ordinary rule of resolving the absolute velocity into its two components—peripheral and relative. The entrance elements of the blade are supposed to be drawn upon corresponding *cones*, whose vertices will be at *A*, *B*, *C*, and *D* respectively. These cones we now develop upon a plane as shown in the diagrams in the upper part of the drawing. The diagram *E* belongs to the point *E* of the entrance curve. In this particular case we have a portion of a cylinder to be developed instead of that of a cone, and the corresponding elements of the blade will be straight lines instead of being curved, as is the case for all other points of the entrance line as shown in diagrams *A*, *B*, *C*, and *D*. (Involutes are recommended for the inlet elements of the blades. It is easy enough to draw an involute, bearing in mind that $d = D \sin \alpha$, where d is the diameter of the generating circle, D is the diameter of inlet, and α the angle of inlet at the corresponding diameter, D.)

We now wrap the diagrams upon corresponding cones and draw the plan view of the blades as shown in Fig. 7. So far as the discharge elements of the blades are concerned, it may be mentioned that the discharge angles are chosen according to general practice and to the fancy of the designer. Our immediate task is properly to transfer the diagrams and thereby to determine the suction elements of the vanes. On the plan view, Fig. 7, we draw circles with radii, such as, for instance, *Oa* (for diagram *B*), and transfer various points from

diagram *B* upon Fig. 7, so that, for instance, *a–a* (diagram *B*) = *a–a* (Fig. 7). For each diagram we need only three points and three circles, such as *Oa*, *Ob*, and *Oc*.

In this manner we have obtained the suction tips of the blades; connecting them to the discharge tips is a matter of judgment and can be done in several ways. The next step is to lay out the lines of intersection of the blade surfaces with planes ⊥ to the shaft (such as 1–1, 2–2, etc., see Fig. 6). Radial lines are drawn, such as 0–5, 0–6, etc. (Fig. 7), using the diagram *E* for determining its angular distance from the center line.

The intersection of 0–6 with such lines as 1, 2, 3, etc. (Fig. 7), gives us the curve 6–*VI* (Fig. 6); for instance, the intersection of 0–6 and the line 2 (Fig. 7) is *Z*, and the distance 0–*Z* (Fig. 7) gives the corresponding point *Z* in Fig. 6, thus forming the line 6–*VI* (Fig. 6).

Having obtained lines similar to 6–*VI* (Fig. 6) we plot their intersections with 1–1, 2–2, 3–3, etc. (Fig. 6). For instance, the line 6–*VI* (Fig. 7) is formed as follows: Upon the radial line 0–6 (Fig. 7) we lay out the distance 6–6 (Fig. 6); again, upon the radials 0–7 and 0–8 we mark the intersection of 6–6 with the lines 7–*VII* and 8–*VIII* (Fig. 6), and the line 6–*VI* (Fig. 7) is the section of the blade with the transverse plane 6–6 (Fig. 6).

PAPER NO. 1102.

SOME ENGINEERING FEATURES OF ELECTRIC FURNACES.

CARL HERING.

(Active Member.)

Read March 4, 1911.

As it is such a simple matter to convert electric energy into heat, electric furnaces have to a large extent been designed and constructed by metallurgists and chemists rather than by engineers; almost any crude electric contrivance will produce heat, and hence was good enough; the main question was: Will it perform the necessary metallurgical, physical, or chemical reactions? Now that the latter has been demonstrated beyond question for a large variety of processes, the inevitable question naturally arises, "Will it pay" to use electric heat? To determine this it becomes necessary to design and construct the furnaces so that they will have the highest possible heat efficiency; that is, to reduce the inevitable heat losses to the least possible. This is of far greater importance for electric furnaces than for those using the combustion of fuel, as the cost of a unit of heat is generally considerably greater when produced electrically than when generated directly by combustion. Fuel furnaces are, as a rule, so very wasteful that their design is of little or no aid in designing electric furnaces. The important problem of to-day, therefore, in connection wih electric furnaces, is that of their design and construction so as to make them as perfect an engineering structure as possible, hence it falls into the province of the engineer as distinguished from the chemist or metallurgist.

The purpose of this present paper is to point out and discuss briefly some of these engineering features which are involved in the design and construction of electric furnaces, with a view to perfecting them as engineering structures.

Before doing so, however, it may be well to dispel the prevalent idea that the electric furnace is still only a laboratory device or a mere fad. It is true that it is not as commonly seen as many other

electric devices, and that, being generally an enclosed structure, the operation in its interior is not generally appreciated by the layman, but statistics show that there are hundreds of large furnaces in daily use, many of which have been in successful use commercially for many years, and that they produce thousands of tons of products daily. Some of them produce well-known products cheaper or better than fuel furnaces do, while in others products are made which were never known before, or which could not be produced commercially in other furnaces. Among the former may be mentioned aluminum, steel, ferro alloys, bisulphid of carbon, phosphorus, etc.; among the latter, carborundum, calcium carbid, artificial graphite, silicon, siloxicon, alundum, oxidized nitrogen, etc.

Some of the industries developed by the electric furnace even promise to affect the wealth of nations. Sweden, for instance, was losing its great iron industry owing to the greatly increased cost of charcoal; but with its large available water-powers, the electric furnace, which requires far less charcoal than the blast furnace does, promises to recover this great national industry again for that country. The barren, rocky, western coast of Norway, apparently useless for most other purposes, bids fair to develop wealth-producing industries of national importance, due to the electric furnace operated by the numerous easily regulated water-powers on the seacoast, where transportation will never be restricted by railroad monopolies. Canada and the Pacific coast are other districts which will be enriched by the electric furnace used as a connecting-link between the mineral resources and the water-powers.

There are about seventy to eighty electric arc furnaces in operation or building for refining steel, mostly in France and Germany; in Norway, Sweden, and California there are several for the reduction of iron ore. Of induction furnaces for steel refining, there are said to be between thirty and forty in operation or building, mostly in Germany. About 17 tons of artificial graphite, which in many respects is better than the natural product, are produced daily in the electric furnace; also about 6 tons of bisulphid of carbon, and all of the aluminum.

In the early history of our earth it was a seething mass of liquid and gases at exceedingly high temperatures, at which most chemical affinities cease to exist; hence the elements were mostly free and uncombined. As it cooled, the chemical forces which cause these elements

to combine into compounds began to act; the elements became mated; the bonds grew stronger and stronger, forming the rock, water, and gases which constitute the present crust of the earth as we know it now. For the first time during these millions of years we are now enabled, by means of the electric furnace, to reproduce, or at least to approach, those original high temperatures again; hence these rocks may now be again separated into their constituent elements, and by producing proper artificial surroundings, they may be prevented from recombining again, or may be compelled to recombine differently in order to form desired useful products.

Electric energy is undoubtedly the most available or highest form of energy; that is, it can be most readily converted into the other forms. On the other hand, heat is undoubtedly the least available or most degenerated form; all other forms tend to degenerate into heat; practically all the electric energy generated in our large central stations ultimately degenerates into heat. It therefore requires no skill to convert electric energy into heat; nature will do this for us, and, unlike as in other conversions, it does it at a virtually 100 per cent. efficiency. It is the reverse operation that requires the greatest skill of the engineer, as it involves the boiler, engine, and dynamo, all three of which are the results of the highest engineering talent.

Hence as a converter of energy the electric furnace is the simplest kind of an apparatus; it is doubtless for this reason that its early development was in the hands of others than engineers. Every arc light, for instance, is a small high-temperature electric furnace, and to get more heat the arc was simply made larger (by increasing the current, not its length) or several arcs were used.

For commercial furnace processes, however, the inevitable question, "Does it pay?" becomes of prime importance, and this involves the economy of the more expensive electric heat; that is, the reduction of the thermal losses or the increase of the heat efficiency. And as an electric furnace is, or should be, enclosed, the radiation and convection losses are reduced to the least possible, leaving as the chief loss that of conduction through the walls and the electrodes which must necessarily pass through them. The latter, therefore, constitutes the chief problem for the engineer.

Conduction of heat through solid bodies may be said to be a true flow of energy in the form of heat. This flow may in many of its features be likened to a flow of electricity through an electric conductor, except that the flow of heat is very slow, while that of elec-

tricity is practically instantaneous. It is also like a flow of water through a porous material.

Quantitatively, the flow in heat units per second is directly proportional to that which causes it, namely, the difference of temperature; and inversely to that which opposes it, namely, the thermal resistance of the body, which is the reciprocal of what is generally termed the conductivity (more correctly, the conductance) of the body. Hence the quantitative law is exactly like the law of Ohm, which is the fundamental law of electric flow. And if the units are properly chosen, the coefficient also becomes unity, as it is in Ohm's law, hence the flow is then numerically equal to the difference of temperature divided by the resistance; the formula for its calculation therefore may be reduced to the simplest and most elementary kind.*

The study of such flows of heat through bodies does not seem to have been given the attention which it deserves; it applies also to other branches of engineering, such as refrigeration, the heat insulation of engine cylinders and steam-pipes, the transmission of heat from the hot gases in a boiler to the water, the construction of thermos bottles, etc. A postage-stamp pasted on the fire side of a steam-boiler tube will not even be charred by the flames, showing the existence of an enormous resistance to heat flow on the outside of the tube; a study of the phenomenon of the flow of heat showed how this resistance can be diminished, resulting in a much greater flow, hence increased steaming capacity. An excessive heat insulation of a gas-engine cylinder would result in its destruction. The over-insulation of steam-pipes, which is said to be quite common practice in this country, results in the waste of more money for the covering than the saving of steam warrants. All such engineering problems would be simplified by giving this subject of the flow of heat more attention. The lack of proper units and physical constants for such calculations is doubtless responsible in part for the neglect of due consideration of this branch of engineering.

Before discussing some of the applications of the laws of the flow of heat to the design and construction of electric furnaces, let us summarize briefly the general features of the furnaces themselves.

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* See "Thermal Resistance and Conductance; the Thermal Ohm and Thermal Mho," by Carl Hering (Metallurgical and Chemical Engineering, January, 1911, vol. ix, p. 13).

In general, there are two classes—resistance and arc furnaces. In the former the heat is generated in the interior of a conductor, due to the resistance offered by the material to the passage of a current through it. The ordinary incandescent electric lamp is a simple illustration of the generation of heat in this way. In the arc furnaces the heat is generated by the passage of a current through a gap formed between the ends of two conductors; the bridging of this gap by the current is called the electric arc. The ordinary arc lamp used in streets and halls is a simple illustration of the generation of heat in this way.

The general characteristics of these two classes of furnaces are as follows. In the resistance furnace the current may be passed through the material itself which is to be treated, or it may be passed through a permanent near-by conductor, and transmitted to the material to be treated by radiation, conduction, and convection.

When the heat is generated in the material itself, the heating becomes very efficient, practically 100 per cent., as all the heat is generated in the body itself, where it is wanted. This is therefore the most efficient method; it is also generally the most rapid, as no time is lost for the heat to penetrate by the slow process of conduction, from the outside to the inside; it is all in the inside when it is generated, and it can be generated very fast by simply increasing the current. Hence in some respects it is the ideal method. As long as the material remains solid, there is apparently no limit to the temperature which may be reached, for by continuing the passage of the current, heat continues to be generated, and if it cannot escape, it accumulates, thereby continually raising the temperature until the losses equal the input. This is the case in the graphite and carborundum furnaces, in which exceedingly high temperatures are obtained, estimated to be from 2300° C. to 4000° C. (4000° F. to 7500° F.).

If, however, the material through which the current passes becomes liquid, generally in an open channel, there is a very decided and sometimes very serious limit to the temperature which can be produced, for when the current reaches a certain value, dependent on the cross-section and the density of the material, a formerly unrecognized force comes into play, which contracts the column of liquid until it is severed completely, and this, of course, interrupts the current. This peculiar phenomenon was encountered, studied, and described by the writer some years ago, and termed by him the "pinch phenomenon," by which name it is now generally known here and

abroad. By submerging these channels of liquid deeply below the surface, the writer found that this pinching force may not only be prevented from interrupting the circuit, but may even be used to cause the liquid in the confined channel to flow out of it as quickly as it is heated, whereby it also produces much desired circulation.* Such a furnace, then, has the desirable qualities of one with solid resisters, besides some new qualities due to the rapid circulation of the heated liquid.

The electrodes of such furnaces, which conduct the current from the outside of the furnace to the inside, are one of the most important elements, as also one of the most troublesome. To dispense with them, therefore, seemed a great improvement. This is accomplished in the induction furnace, and is its chief advantage; in such furnaces the current which does the heating is generated by induction in the metal in a trough, forming a complete circuit through which the current can circulate; hence it requires no direct connections with outside circuits. It therefore has some advantages over furnaces which require electrodes. Among its disadvantages are: its complicated construction and greater cost; the difficulty of preventing excessive losses of heat because the heated material necessarily exposes a very large surface to such losses; its low power factor, which means larger and more expensive electric machinery, especially so for the larger furnaces, etc.

The characteristics of the arc furnaces are briefly as follows: The temperature of the arc is always that of the volatilization of the material of the electrodes between which the arc plays, and as these are generally carbon or graphite which have extremely high vaporization temperatures, it follows that the temperatures developed in such arc furnaces are exceedingly high—generally far above what is required. This heat is, however, all generated in the arc itself, and at the surfaces between which the arc plays; hence it can reach the main body of the material to be treated only by radiation, conduction, and convection, and this necessarily takes time; the exceedingly high arc temperature aids this. In heating liquids with an arc, much of the energy must necessarily radiate upward, hence is not utilized, and even tends to destroy the roof of the furnace. Moreover, heating a

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* See "A New Type of Furnace," Trans. Amer. Electrochem. Soc., vol. xix, 1911, p. 255; also "Electric Furnaces," Journal of the Franklin Institute, vol. clxii, July, 1911, p. 55.

liquid from the top surface is not the most rational way, as the heat travels downward with difficulty and quite slowly, hence it takes time for the heat to penetrate; this is also the case in open-hearth furnaces. The electrodes in arc furnaces are consumed, and therefore require continuous feeding, or else the arc goes out. Some and perhaps considerable of the electric energy for such furnaces is necessarily consumed in volatilizing the electrode material, although part of this may be again recovered.

In many of the chemical reactions which it is intended to have take place in furnace processes, more particularly in those conducted in electric furnaces, energy is consumed by being stored up in the product formed, just as energy is stored in compressing air in tanks. In the formation of calcium carbid, for instance, in the electric furnaces at Niagara Falls, part of the energy of the falls is stored as chemical energy in this material, and it can be set free again later as desired, as light or heat. An electric furnace must therefore also supply this energy, besides merely generating the heat required for the reaction to take place. Sometimes—as in the reduction of aluminum, for instance—this stored energy becomes very great.

Some of the chief differences in the characteristics of combustion furnaces and those operated by electric energy are best shown by the curves in Fig. 1. Let the vertical distances represent temperatures, and the horizontal ones the costs of heating a given quantity of a material to those temperatures. The curve for the combustion furnace will be seen to rise quickly at first, showing low and only slowly increasing costs; for the higher temperatures it becomes flatter, showing rapidly increasing costs; finally, a maximum temperature is reached beyond which it is not possible to go, as the temperature would diminish again. This latter point is reached when the air-blast is so great that the flue gases carry off the heat as fast as it can be generated by the fuel. When this point is exceeded, the fire goes out, as is illustrated by the blowing out of a candle-flame; the volume of air then is so great that the flame can no longer heat it, hence the wick chills and the flame goes out. These maximum temperatures are approached in steel furnaces. The chief feature of this curve is that at these high temperatures the cost increases very rapidly; regenerators, for instance, will increase the temperature, but at considerable cost.

The corresponding curve for the electric furnaces is approximately a straight inclined line as shown, which intersects the other. This

means that the cost increases roughly proportionately with the temperature, and there is no definite maximum within practical limits. Hence for the lower temperatures the combustion heat is generally the cheaper; at a certain higher temperature they are equal; above that the electric heat is the cheaper, and for very high temperatures it is the only available means. For temperatures above this intersection point the cheapest method, therefore, is to use a combination of both, fuel being used for the lower temperature heat, and electric energy for the higher. This is what is common practice now in the

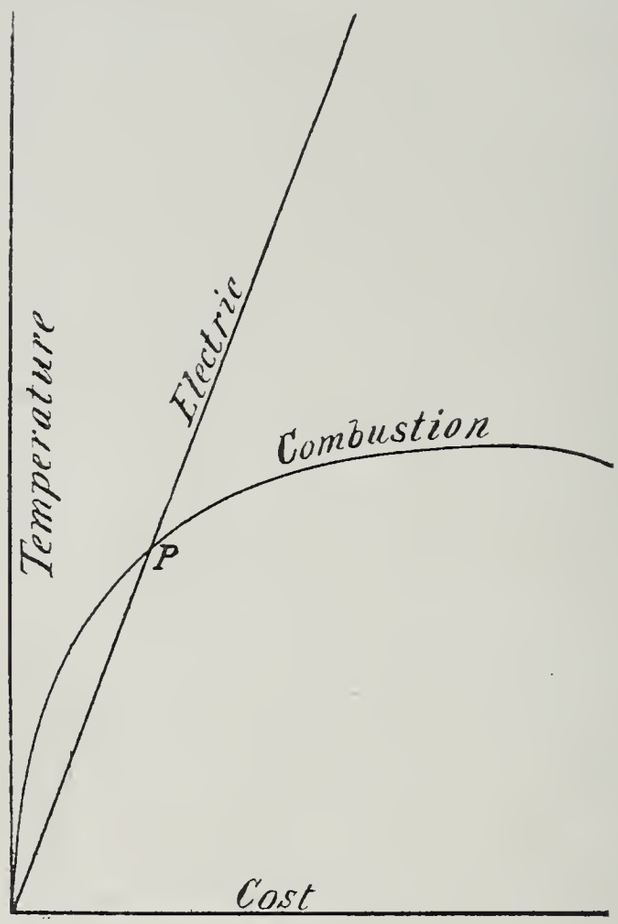

Fig. 1.

electric steel industry, in which the cold metal is first melted by means of fuel heat and then transferred to the electric furnace for treatment at the higher temperatures. These curves will, of course, vary greatly with the cost of coal and water-power; they are given here to show only very general characteristics.

Other characteristics of the electric furnaces are that there are no chimney gases with their attending losses, including those carried away by the useless nitrogen; there is no lighting of fires necessary; the generation of heat is accomplished very quickly; the atmosphere

is neutral; the control of the heat is far more simple and perfect, etc.

As was stated above, the thermal efficiency of an electric furnace is the most important feature from the standpoint of the designing engineer, as it is the cost of the energy which is generally the criterion as to whether "it will pay" to use the electric furnace; an increase in the thermal efficiency means a decreased cost of this expensive form of energy. Hence after the metallurgist has established the necessary conditions as to temperature, quantity of heat, interior capacity, etc., it is for the engineer so to construct the furnace that the heat losses will become as low as practicable.

As all electric furnaces are or should be enclosed, there are two sources of loss of heat—the heat which flows out through the walls, and that which flows out through the electrodes. Until a few years ago our knowledge of the data, laws, and rules of construction concerning these two losses of heat were so crude, inadequate, unreliable, and unsatisfactory that the writer made analytic researches to determine the underlying principles and laws governing correct design, the results of which showed that in part our former practice was positively wrong, and had led us away from, instead of toward, the correct design. These researches have been fully described and published elsewhere by the writer; the results may be briefly summarized as follows:

The general law for the quantitative determination of the flow of heat through a body has been given above. The difficulties in applying it to the heat leakage through furnace walls lie in the lack of proper units and physical constants of materials, and in the fact that with thick walls, as are used in furnaces, the cross-section of the path of the flow of heat increases greatly from the inside surface to the outside. Suitable units have now been proposed (see above); the physical constants are still badly needed, but some fairly good ones exist and others will probably be forthcoming.

Concerning the flaring cross-section of the path of the flow, the usual rule has been to take the arithmetic mean between the inside and outside. Believing this to be unreliable, the writer some years ago determined the strictly correct formulas for such varying cross-sections* and found that, while the old rule was approximately correct for very thin walls, it was very greatly in error (100 per cent. and more)

* "Heat Conductances through Walls of Furnace," Trans. Amer. Electrochem. Soc., vol. xiv, 1908, p. 215.

for thick ones. The formulas were therefore sorely in need of correction. For a rectangular or spherical furnace the correct mean cross-section was found to be the geometric mean, not the arithmetic.

In the accompanying curves (Fig. 2), taken from the writer's paper, the vertical distances are proportional to the heat losses, and the horizontal ones are the wall thicknesses in terms of the inside diameter, or inside edge of a cube, the curves being limited to spherical, cubical, and cylindrical furnaces, as representing the three typical forms.

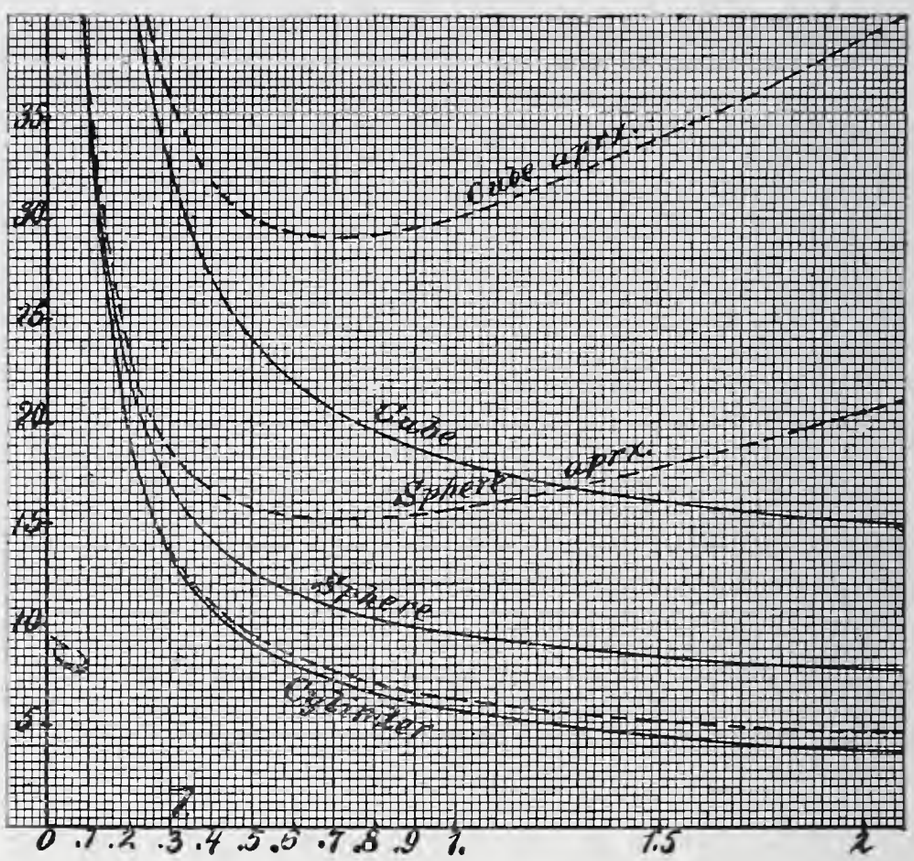

Fig. 2.

It will be seen that at first the loss decreases very rapidly as the wall thickness increases, the curves being very steep. But when the thickness becomes relatively great, the reduction of the losses by a further increase in thickness becomes very small, and a point is reached when it would unquestionably cease being profitable to continue to increase the insulation.

After these correct formulas were published an English engineer applied them to the insulation of steam-pipes, and claimed to have found thereby that Americans over-insulate their steam-pipes; that is, that the cost of this excessive insulation is greater than is warranted by the heat saved thereby.

The dotted curves show the results when the usual formula is used, while the solid ones are those for the correct formulas. It will be seen that not only is their divergence very great for the greater thicknesses, but the dotted lines actually have a minimum point, after which they rise again, which of course would be absurd, as it would mean that a further increase of wall thickness would actually increase the losses again. This shows the danger of using approximate formulas. The curves for the cylindrical forms are not directly comparable with the others, as they are for a cylinder of unit length, and must therefore be multiplied by the length, and the heat losses through the ends must be added.

A further study of these results, as indicated by diagrams in the original paper, shows how very important it is, when this loss is important, to reduce the inside of the furnace as much as possible to hold the required charge; that is, one should not waste any space in the interior by making the inside any larger than necessary, because the wall thickness, to keep the loss down to the same amount, increases very rapidly as the inside becomes larger. Another important result is that for the same percentage loss in small and large furnaces the wall thicknesses become enormously larger for the smaller ones; hence, as far as these losses are concerned, it is far more economical to use one furnace of the total capacity than to use several smaller ones which are together equal to the large one. For the same wall thickness, relatively to the inside dimensions, the losses per unit capacity—that is, per pound of metal melted—diminish rapidly as the furnaces become larger. Further results and details are given in the original paper.

The loss of heat through and in the electrodes is a far more complicated matter. These electrodes, which extend from the cold outside to the hot inside, generally have to carry very large currents; they ought for this reason to be made of a good electric conductor, large in section and short, in order not to waste energy due to their electric resistance. On the other hand, when thus made they carry off large quantities of heat from the interior of the furnace, because a good electric conductor is generally also a good heat conductor. When they lead off much heat, it chills the product in the interior of the furnace, thereby diminishing the available interior space,—that is, the capacity,—and the heat efficiency becomes poor. The conditions for leading off as little heat as possible are directly opposite to those mentioned above for diminishing the electric resistance losses;

that is, they should be made small in section, long, and of poorly conducting material.

In view of these conflicting conditions the question arises: What are the conditions under which the total losses, made up of both the electric and the thermal losses, are the least? With the aid of the calculus, these conditions for the minimum total loss can be readily determined under simplifying assumptions. These determinations were made by the writer some years ago,* and although they showed that our former practice had in many respects been entirely wrong, having led us away from, rather than toward, the correct result, it is believed to be generally conceded now that they are correct, and that our former practice was not. It afforded a good illustration of the importance of first making a thorough mathematical analysis, when the conditions are complicated and conflicting, before formulating practical rules of thumb for the constructor.

The results are given and discussed in detail in the original paper; the chief ones are as follows: Heat is generated by the current in the electrode; this, being generally at a lower temperature than the interior of the furnace, flows out at the cold end. As long as the end of the electrode which is in the interior of the furnace is cooler than the heated product under treatment, heat must necessarily be abstracted from this product, and will flow out through the electrode, thereby chilling the product. This latter loss of heat could be stopped entirely if the hot end of the electrode were at the same temperature as the heated product, for heat will flow only when there is a difference of temperature. If, therefore, the electrode is given such a cross-section and length that the heat generated in it by the current raises the inside end to the furnace temperature, then this desired result of stopping this abstraction of heat from the furnace product will be accomplished.

At first thought it seemed absurd actually to increase the electrode resistance in order to save energy. The analysis, however, showed that by thus intentionally increasing one of the losses, the other was reduced in a greater proportion; hence the total was less, and became a minimum when the above-mentioned conditions were fulfilled.

A simple water analogy (though not a perfectly parallel one) is shown in Fig. 3. Let P be a tank of water, to the bottom of which an

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* "Laws of Electrode Losses," Trans. Amer. Electrochem. Soc., vol. xvi, 1909, p. 265.

open pipe is connected. Let the required conditions be that this pipe cannot be closed, yet no water shall flow out of the tank through the pipe. This can be accomplished by forcing water into this pipe, from other sources, at such a rate that the pressure at the tank end of the pipe will be equal to that in the tank. A static pressure is thus produced dynamically.

Former practice had led to making the electrodes larger and larger, to keep them cool; this made them more and more costly and more difficult to handle. The above analysis shows that they should have been made smaller instead, so as to stop the loss of heat from the furnace product where it is wanted; the heat generated in the electrode costs less than that in the furnace, as it has to be transmitted (as electric energy) over a shorter distance. Such reductions in the size

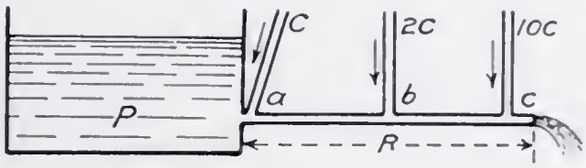


Fig. 3.

of electrodes result in large annual savings not only of power, but of electrode materials also. And it increases the valuable available space in the furnace by not chilling a more or less large part of the product.

This analysis brought to light another fallacy. Formerly it was claimed very positively by certain parties that graphite was a worse material to use than carbon, on account of its much higher heat conductivity; it was claimed to "chill the product too much," and therefore very wasteful of energy. The above analysis showed that this too was an error, as this chilling may be entirely prevented by proper proportioning; and when thus proportioned graphite is even less wasteful than carbon.

The explanation of this is that the minimum losses and the best proportions do not depend on either the electric or the thermal conductivities alone, but on certain relations between them. Neither property alone is a criterion. This brought out the surprising fact that the best electrode materials, from the standpoint of the least possible electrode losses, and the smallest amount of electrode material, were the metals; and of these, copper, the best of all heat conductors, was decidedly the most economical. Hence electrodes should be made of metals whenever possible, if economy of power and

material is an object. This gives the resistance furnace an important advantage over those using the arc.

Some idea of the quantitative results of those researches are shown in Fig. 4, which gives the sizes and losses of power, for a given furnace, for four different materials, the comparisons on the left being made on the basis of the same length; and those on the right, on the basis of the same cross-section; the energy losses, shown by black lines, are the same in both.

In conclusion, attention may be called to the fact that although, as a rule, electric heat is more expensive than fuel heat, yet in electric furnaces it is generally possible to apply the heat much more economically, and greatly to reduce the thermal losses, by proper and careful design, so that the total cost of the thermal operation in many

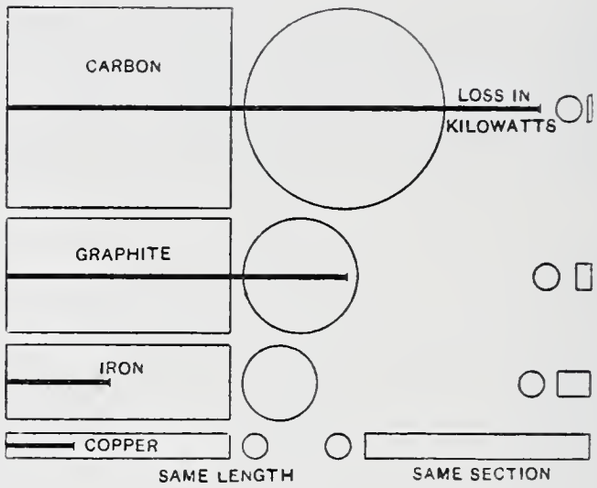


Fig. 4.

cases becomes less, and that is after all the deciding factor in most cases. When a furnace is properly designed to reduce the thermal losses to the least possible, it is believed by the writer that it will soon be economical to replace some of the present fuel furnaces by electric furnaces for commercial work, even when the electric power has to be purchased from the supply in cities. There are, of course, other factors involved also, such as the reduction of labor, the better quality of the materials produced, the rapidity of heating, etc., all of which should be taken into consideration.

The development of the commercial electric furnace will, therefore, depend largely on the work of the engineer to design it with a view to obtaining the best possible economy in cents per pound of final product, and in this the reduction of the losses is one of the chief factors.

PAPER NO. 1103.

THE SUPERSTRUCTURE OF THE PASSYUNK BRIDGE.

HENRY H. QUIMBY

(Active Member.)

Read February 18, 1911.

AT the meeting of the Club on September 18, 1909, a paper was presented describing the substructure work of the Passyunk Bridge, which crosses the Schuylkill River on the line of Passyunk Avenue at Point Breeze, Philadelphia. The superstructure has since been erected, and is now ready for the paving, which is also to be done under the present contract.

The bridge is 1323 feet long, with a 38 feet driveway and two 9 feet 6 inch sidewalks, making a total width of 57 feet. The driveway is to be paved with asphalt, except on the bascule span, where it will be of creosoted wood plank, and the sidewalks and curbs will be granolithic, except on the bascule span, where they will be of uncreosoted yellow pine..

The main channel span, which gives a clear waterway of 200 feet and a clear height throughout this width of about 35 feet above high-water line, is a through-truss trunnion bascule of two leaves. The approach spans at both sides are deck construction. The flank spans, immediately adjoining the channel span, are each carried by two lattice riveted trusses of 126 feet, center to center of piers. The eight approach spans on the west side of the river are 100 feet each, with three lines of plate-girders in alternate fixed or anchor spans, and cantilevered with suspended spans. The extreme east approach span is 47 feet, consisting of 25 feet of cantilever from the lattice span and 22 feet of I-beam construction with concrete floor arches.

The foundations of the west abutment and all the piers except the channel piers are wooden piles capped with concrete. The two channel piers were carried to bed-rock by compressed-air caissons of wood, the east pier No. 10 reaching a depth of 89 feet below city datum, which is 2.25 feet above mean high water. The west channel pier No. 9 found rock at a general elevation of about −85. These two piers, therefore, are of solid concrete, approximately 100 feet

high. The piles of the piers on the west side of the river are in mud from 30 to 40 feet deep, and were driven from 8 to 12 feet into a bed of gravel, and were cut off for capping at about low-water line. All these piers and the west abutment are surrounded by spur or batter piles, to prevent any possible future lateral dislodgement of the foundations by either filling or construction of other works along one side, the mud being quite mobile. The spur piles were driven at as great an angle as the pile-driving plant could be made to work, varying from 15 to 30 degrees from the vertical. A capping of concrete 4 feet deep was cast around the heads of the piles, to give them transverse fixity, inasmuch as they were required to act as columns because of the softness of the mud with which they were surrounded. This firm embedment at both ends gives to each pile two points of contraflexure and, therefore, high resistance to buckling.

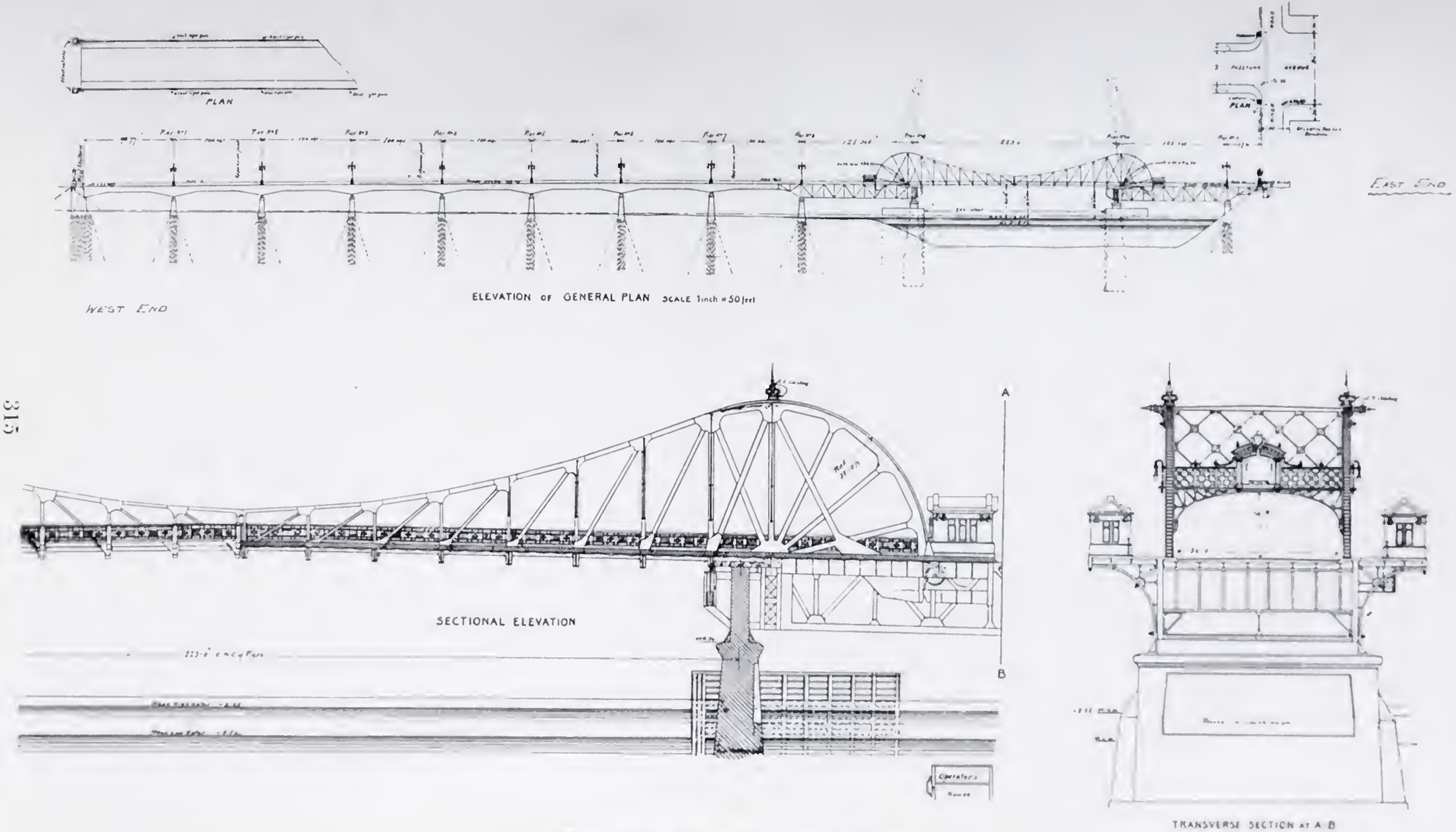
The superstructure of all the piers is rubble concrete, made by depositing crushed stone concrete, and embedding in it stones of, approximately, one-man size.

All concrete was given a granolithic surface finish by placing granolithic facing mortar against the forms, and removing the forms within twenty-four hours, and scrubbing the surface to expose the fine stone aggregate.

The bascule type of draw span was decided upon for this crossing because of a sharp bend in the channel of the river, which made it impracticable to construct an ordinary swing span that would give sufficient leeway for the manœuvering of large vessels. The bridge crosses the river close to the apex of the bend in the channel, and the "protection" that would be required for a swing span of sufficient length to bridge the channel would extend so far across the apex that it would be extremely difficult to navigate long vessels through the opening. Some of the largest vessels that come to the port of Philadelphia are docked in the Schuylkill above this bridge, and are, therefore, required to be accommodated by the channel span.

In order to determine the required opening of the draw, and to ascertain whether it would be practicable to construct a swing bridge, before the design of the bridge was definitely decided upon scows were moored in the river in the position that would be occupied by the "protection" that a swing draw would require, and the effort to steer large vessels past them in the channel made it clear that some other form of draw than the swing bridge would be required.

A retractile form of draw was considered, and plans developed for it,



Passyunk Bridge—General Plan.

but the expense of constructing a suitable yard for it on the west side of the river, and the fact that such a yard in Passyunk Avenue on the east side of the river would somewhat obstruct River Road during times when the bridge was open, caused the retractile to be abandoned and the bascule type to be adopted. The retractile type of bridge has the two advantages of the rigidity of a fixed span for street service, and of great lateral stiffness to resist the possible blow of floating vessels. If the conditions of the approaches would render such a type feasible, it would have been lower in cost and preferable to the bascule type.

The type of bascule adopted is the trunnion type, with a form of truss developed in Chicago, Ill., which forms a very pleasing outline, and has the counterweight and all the machinery concealed below the floor of the bridge, and is rigid and economical in material.

An important feature was added to the Chicago type in the outboard bearing, by means of which the cantilever length for live-load service is reduced, and the stiffness, therefore, increased, and the live-load stresses in the anchor arm become but little more than the dead-load stresses.

The distance center to center of channel piers is 223 feet. The trunnions are set 7 feet back of the center of the pier, making the span 237 feet between trunnions, and each leaf 118 feet 6 inches long. The trusses of the flank spans, upon which the trunnions rest, are extended over the channel side of the piers sufficiently to give a bearing for the first panel point of the bascule truss 6 feet 6 inches from the center line of the pier. The first channel panel, therefore, of the bascule truss is 13 feet 6 inches, by which amount the cantilever arm is shortened, and the anchor arm lengthened, for live-load service. In consequence of this the counterweight, which exactly balances the dead weight of the leaf around the trunnion as a center of gravity, is nearly sufficient to counterbalance the live load on the cantilever arm acting about the outboard bearing. The full calculated live load of 90 pounds on every square foot of the cantilever arm will produce only 35 tons negative reaction or anchorage uplift at the heel of each truss where it is hooked into the structure of the flank span.

The use of this outboard bearing creates reversal of stresses in several of the members of the truss back of this point, but makes only a slight increase in any of them beyond the stresses produced by dead load alone, and the reversal will occur gradually as the live load advances on the cantilever leaf.

The live loads for which the bridge was designed are a general live load of 90 pounds per square foot over the whole area, sidewalks and driveway, or 110 pounds per square foot on individual panels of the sidewalk, and concentrated loads in the driveway of two lines of street railway cars weighing 36 tons each on wheel base of 25 feet, and occupying each a width of 10 feet, or a truck weighing 40 tons on two axles 20 feet apart at any point of the driveway.

The unit stresses in the flanges of the plate girders of the approach and in the chords and web members of the latticed flank spans were the standard specifications for bridges of the Bureau of Surveys, City of Philadelphia, Mr. George S. Webster, Chief Engineer.

Tension, $10{,}000 \left(1 + \frac{\text{min}}{\text{max}}\right)$, not exceeding 15,000 pounds per sq. in.

Compression $\left(14{,}000 - 40 \frac{l}{r}\right) \left(1 + \frac{\text{min}}{\text{max}}\right)$.

The unit stresses in the trusses of the bascule leaves were arbitrarily adjusted to reduce the tension in members over the reaction points to 12,000 pounds maximum, increasing by 500 pounds per sq. in. for each panel to 15,000 pounds at the extreme end, on the theory that the effect of impact will be greatest at the point of greatest rigidity, and will decrease as the flexibility of the truss increases. The most considerable impact will be that possible to be produced by careless operation—say, in closing the leaves down too suddenly. For this there is, besides the provision of pneumatic buffers to absorb such a shock, the fact of the dead-load stresses being only from 40 to 45 per cent. of the maximum stresses for which the sections are proportioned, giving really very conservative strains.

The plate girders of the west approach were originally designed so that they could be shipped in 50 foot lengths and erected upon two bents of falsework in each span, and riveted up in position. The cantilevers of these spans are 25 feet long, leaving the suspended spans 50 feet long. The girders, however, by arrangement between the shops and the erectors, were riveted up at the shops in lengths from 50 feet to 112 feet 6 inches, bringing the field splices always 12 feet 6 inches from the center pier, except in the case of the joints of the suspended spans and cantilever arms. This arrangement permitted the erection of all the spans, except the flank spans, by means of a traveler, with a boom sufficiently long to reach over more than half of one span. The derrick used had a steel boom 85 feet long, competent to handle 40 tons in its horizontal position. The heaviest girder handled weighed 25 tons.

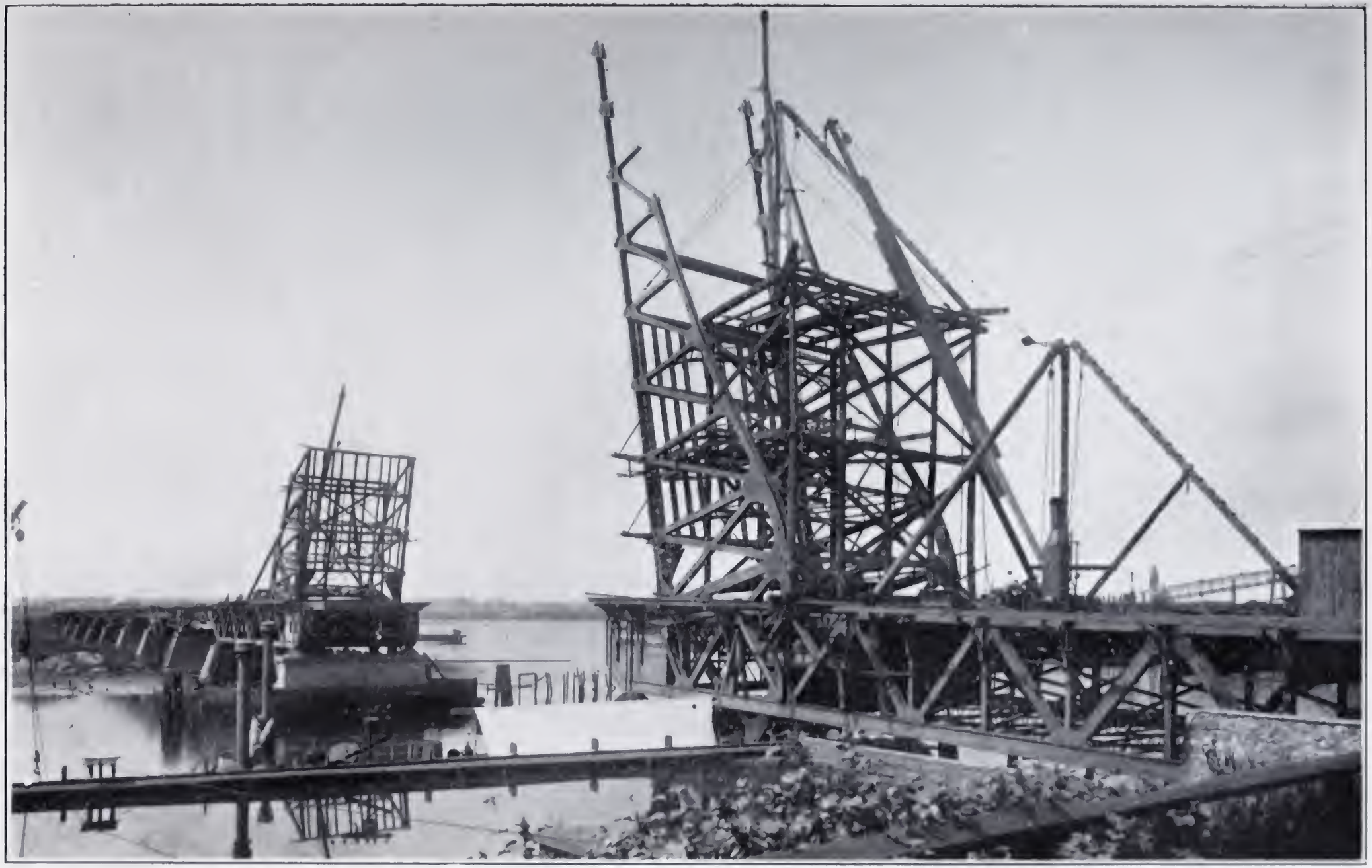
Expansion points were established in alternate spans, giving, generally, 200 feet of fixed length. No provision was made for sliding of girders on the piers, it being intended that the expansion and contraction of the fixed spans of the bridge should be accommodated by a slight swinging of the piers on their pile foundations, together with a slight straddling of the steelwork that would accompany the rise and fall of the middle of the spans in changes of atmospheric temperature. The girders are 10 feet deep over the piers and 6 feet deep for the 50 foot length of mid-span, producing an arched effect in the bridge, and an arching effect in the action under thermal changes. This shape of girders was found to be economical of material, and facilitates automatic adjustment to changes in length from temperature, and also affords some additional clearance for river craft that might be floating under the bridge on freshets. The arrangement thus locks the piers together in pairs without the use of any roller nests.

The sidewalks throughout the bridge are carried on overhanging brackets.

The riveted lattice flank spans are reduced in depth at the ends supporting the bascule leaves, and are there made with web plates and stiffeners, forming in each case a box which has been filled with concrete for stiffness and for protection against rust, except that the compartment in each truss directly under the trunnion has been left open, with a manhole at the bottom to give access to the riveting of the trunnion seat.

A 4 foot thick wall of concrete has been carried up on each pier between the flank span trusses, to increase the resistance of the superstructure of the bridge, in the event of a floating vessel striking the bridge floor. This 4 foot wall is integral with a concrete section of the bridge floor, against which the floor of the bascule leaf is locked when the bridge is closed.

The floor of the bascule leaves consists of buckled plates over the whole area of the driveway, supported by the stringers and floor-beams and riveted to the bottom chords of the bascule trusses. The buckle plates support creosoted wood blocking, upon which the creosoted nailing strips of the floor rest. The wearing surface consists of 2 inch by 4 inch creosoted yellow pine plank set on edge, and each plank toe-nailed to the nailing strips. The buckled plates are $\frac{5}{16}$ inch thick, and were adopted because they constitute an economical and very effective horizontal lateral system, with the very great ad-



Passyunk Bridge—Erecting Trusses of Draw.

vantage, also, of effectively supporting the bottom chords of the truss against buckling under stress or under the blow of a vessel's masts. The buckled plates also afforded adequate support for the wooden floor members. Any other form of support would have required either a larger number of steel stringers or much heavier wooden stringers to enable the 4 inch floor plank to carry the 10-ton wheel loads for which the whole bridge is designed, and would have required a heavy and expensive system of diagonal lateral braces.

The bracing of the bottom chords of the bascule truss by the buckled plates is regarded as a very valuable feature, because of the serious danger to such a structure of the masts of a floating vessel striking the bottom chords, which are compression members, and the liability to their collapse under such force.

In order to provide sufficient resistance to slewing of the bascule leaves under the impact of a vessel striking them, the trunnion boxes have been very securely connected to the top chords of the flank spans by means of cast-iron grouting between the trunnion boxes and the large steel castings riveted into the flank span truss chords. The top surface of the steel castings in the trusses and the under surface of the trunnion boxes were both made with gridiron recesses, and, after the bascule leaves had been erected and lowered into position and found to line up truly with each other, the space between the gridiron surfaces was poured full of molten cast iron, which was melted by the street cupola of the street railway company. In erection, the trunnion boxes were blocked up on pairs of planed steel wedges by means of which they were adjusted to exact level before the trunnions were placed in them. The trunnions are 22 inches in diameter and 6 feet long.

The fixed floor on the flank spans is extended past the trunnions to the transverse girder, which carries the outboard bearing, and is so shaped in plan as to permit of large gusset panels in the floor of the bascule leaf, and in the angles between the bascule floor and the fixed floor are fitted steel castings which are provided to receive the impact of any lateral blow on the floor of the bascule leaf, and transmit it immediately to the solid fixed floor and the body of the pier.

The bascule trusses are about 35 feet high over the trunnion, and curve down in the cantilever to a depth of 8 feet at the river end. It is, therefore, possible to brace, transversely, only five of the bents of the trusses. The outer four bents, however, are knee-braced to the floor beams, and the top chord is also in tension, and, therefore, sufficient transverse rigidity is obtained.

The anchor ends of the trusses are segmental, with a radius of 35 feet, and contain $5\frac{1}{2}$ inch pins, 11 inches on centers, which constitute the rack by means of which the leaf is operated. These anchor ends pass down through a slot in the floor 24 inches wide, which is closed by a horizontal plate flush with the sidewalk when the leaves are closed. It is, of course, impossible to have any transverse bracing between these segments, and the spokes which support the segments, therefore, depend upon their riveting to the large plate gussets which are riveted to the cast-steel hubs on the trunnion. The bracing thus provided is found to be ample, no tendency being shown for any wabbling of the segments under operation. The main driving pinions are 30 inches pitch diameter of cast steel, with 11 inch pitch of teeth. Each pair of pinions operating a leaf is connected together by a 9 inch shaft, which is driven by a train of steel gears, the power being furnished by two 75 horsepower motors connected to the same countershaft. Thus, if one motor of the pair should get out of order, the other motor will be sufficient to operate the leaf, except in case of a very high wind. And, if a break should occur in either of the trains of gears, the other train of gears will operate the leaf through the shaft that connects the main pinions.

A duplicate system of control of motors has been provided, so that the two leaves can be operated from either side of the river. It is intended that, although the two leaves are independent of each other, they shall be operated by one man, the meshing together of the two leaves at the middle being such that it is desirable that the same mind shall control the two leaves.

This meshing of the leaves together at the middle is intended as a safety device to compel careful operation, as well as to constitute a lock which will insure the two leaves deflecting together under load, it being impossible for either leaf to deflect without carrying the other down with it. This meshing consists of pockets and seats so proportioned that the bottom chord of the east leaf bears in a pocket on the west leaf, and the top chord of the east leaf enters under a projection of the top chord of the west leaf.

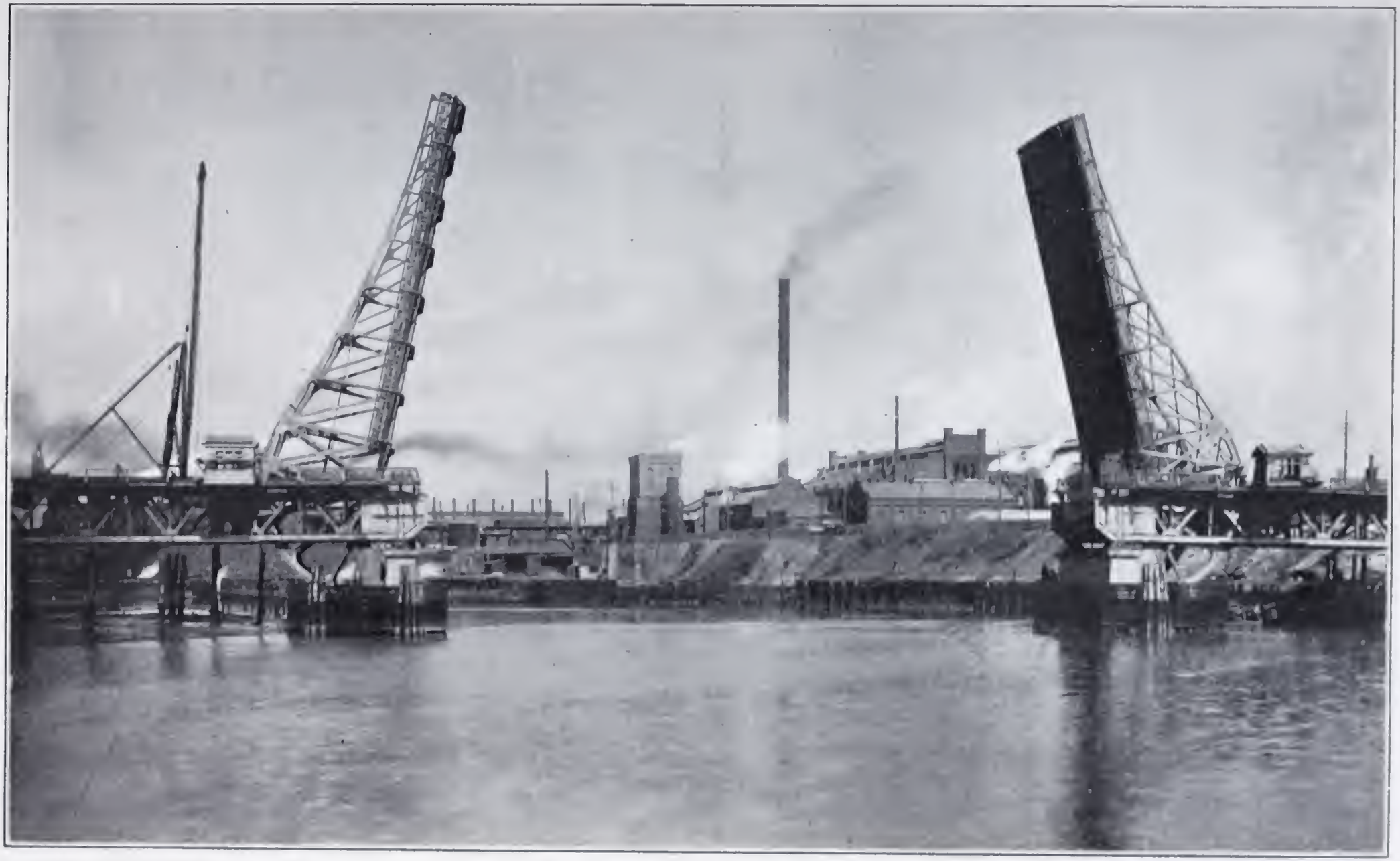
The method of operation thus required consists in lowering the west leaf in advance of the east leaf to a point within about 5 feet of the bearing when the east leaf is brought down, engaging the west leaf on the bottom chord, and pulling the two leaves down together by the machinery of the east leaf. Thus, if the east leaf should be lowered ahead of the west leaf, it would have to be raised again in order to

make the connection; or, if the west leaf should be lowered too far before the east leaf engages it, it would have to be raised again to make the connection, this arrangement operating to prevent the operator from shutting either leaf down too quickly and giving a shock to the structure.

As a further safeguard against a too sudden stoppage of the descending leaves pneumatic buffers have been constructed under the outboard bearings, with a range of throw of 24 inches. Each buffer consists of a cast-steel cylinder, 15 inches inside diameter, with check valve and needle valve in the lower end, and open at the top end, the piston having a 3½ inch diameter rod projecting up through the truss bearing, and being raised by a counterweight on a short lever in the transverse girder. The check valve is to permit the air to enter the cylinder when the piston is raised by the counterweight as the bridge leaf is raised, and the piston, being fitted with rings as in an engine cylinder, compresses the air in the cylinder as the truss descends and presses on the piston rod.

To prevent the bridge from striking the pier when the leaf is raised electric contacts have been set and adjusted to throw off the electric operating current and apply the automatic brakes before the leaf is raised to its fullest extent. Also 6 inch thick rubber buffers have been provided under the heels where they are liable to come in contact with the pier. The motors are provided with solenoid brakes, which are automatically applied to the armature shaft as soon as the current is cut off. The cutting off of the current is by means of circuit-breakers on the switchboards in the operating houses, which go out when the leaves are raised to a certain point, or where an obstruction anywhere causes excessive resistance.

The motors are General Electric Type K, normal rating 75 horse power, series wound, 550 volt, two to each leaf. They are controlled by the indirect or "M" system. By this system the heavy currents carried to the motor are controlled by "contactors," which are operated by light currents from small controllers in the operator's cabin. By this arrangement heavy submarine cables across the river were dispensed with except for the feed wires, the supply of current being all from one side of the river. Current is obtained from the Philadelphia Rapid Transit Company, operating the street railway in Passyunk Avenue, and is furnished by that company to the city without charge. Five submarine cables, armored with No. 2 galvanized iron wire, are used to carry the necessary wires across the



Passyunk Bridge—Draw open.

river for the two systems of control and for the feed wires and signal and telephone wires. The operators' houses are connected by telephone and by electric-bell signals, and have also contact signals—lights—indicating the positions of the two leaves, which show the same in both houses, so that both leaves can be operated from either house, and change from one house to the other can be quickly made by the operator.

Means have been provided for operating each leaf by hand, six men being required on the capstan for each leaf. The electric power raises a leaf from closed to open position in forty-five seconds, and about one-half hour will be required for the six men to make the same movement.

The erection of the superstructure was accomplished by first driving wooden pile falsework under the flank spans, and placing the members of the riveted trusses, and, after they were riveted up, a traveling derrick was erected on them, by means of which the rest of the approach spans were placed.

The bascule trusses were erected in the vertical position, first setting the trunnion boxes, and, after very accurate squaring and leveling of them, placing the trunnions with their hubs, and suspending from them the spokes and counterweight boxes, and segmental chords of the anchor arms. The counterweights are steel plate girder boxes 8 feet wide, 6 feet deep, and 38 feet long, filled with cast-iron blocks. All spaces between the blocks and around them were run full of cement grout. A row of cast-iron blocks was also bolted to the outside of the box, making the total weight hanging on the heel of each leaf about 500 tons.

The truss members for the first four panels were placed and connected, and the bracing between them connected by means of the derrick on the deck of the flank spans. For the erection of the remaining panels a tower 50 feet high was built upon the deck, using withdrawn piles from the falsework; and on top of this tower was erected a stiff leg derrick with a long boom.

Only sufficient of the buckle plates of the floors of the leaves were placed in a vertical position to safely brace the trusses against the wind. After the trusses were lowered into position the remainder of the buckle plates were placed and riveted.

The trunnion boxes were so accurately placed before the erection of the trusses was commenced that, when the two leaves were first lowered into position, they lined up within a fraction of an inch, and

Passyunk Bridge—Draw closed.

locked together by a very slight pulling of one leaf to one side with a rope-twister. The buckle plates which had been put on for bracing had been bolted, so that the play in the holes permitted this slight adjustment. The buckle plates were then riveted up with the leaves locked together, and they retained them in permanent perfect alinement.

Safety gates have been provided in pairs at each portal of the bascule span, each pair connected below the floor, so that the movement of one leaf by the watchman actuates its mate, and one gate of each pair is connected by means of a crank below the floor, and a 2½ inch pipe rod to a 5 inch center lock bolt, designed to lock the two leaves together at the middle of the river. The gate on the east side of the river actuates the locking bolt in the south truss, and the gate on the west side of the river operates the bolt in the north truss. The safety gates are counterweighted, and are hung on ball-bearings in the posts supporting them, and are provided with vertical bolt and horizontal latch to lock them when closed.

The bridge has been constructed under four contracts—a first one covering the west abutment and four piers, which were constructed in 1905 by David Peoples. The second contract covered the two channel piers, which were finished in 1908 by the Filbert Paving and Construction Co. The third covered the remaining five main piers, which were finished in 1909 by McGaw and Gray, and the fourth covered the superstructure complete, and included the east abutment pier, which was built in the bed of Passyunk Avenue on the crest of the bank, and included also the grading and paving of the east approach to the bridge. This contract by the Strobel Steel Construction Co. completes the structure ready for use, though Passyunk Avenue west of the bridge has not yet been graded, and the bridge is, therefore, not yet available for public traffic. The total cost of the bridge, substructure and superstructure, is about $600,000.

DISCUSSION.

J. C. Trautwine, Jr.—Each leaf is a separate cantilever unsupported at the outer end; suppose you had a load on the end of one leaf and no load on the other leaf, what would happen?

Mr. Quimby.—We have provided in the center locks for the transfer of that load—about 35 tons maximum per truss. The leaves must deflect together. The locks allow only about ⅛ inch play.

Wm. Easby, Jr.—How did you determine the shape of the counterweight?

Mr. Quimby.—The bottom of the box was fixed so that it will be plumb when

it approaches the side of the pier as the leaf reaches the open position. The top of the box was determined by the clearance under the stringers when the leaf is closed down, the idea being to get the counterweight as deep as possible. The depth then determined the width, the aim being to get the box as narrow as possible, in order that the center of gravity of the counterweight should be as far from the trunnion and as much below the level of the trunnion as possible. The greater the radius of action of the counterweight, the more effective it is, and the lighter it needs to be.

E. M. Nichols.—Does the counterweight go into the water?

Mr. Quimby.—No; the extreme edge of the segment will just clear mean high water. Of course, we are liable to have freshets which will reach the rack segment, but an occasional immersion will do no harm. It is only rarely necessary to open the bridge to its full height, and therefore on such special occasions the immersion can probably be avoided. The pile fenders around the piers are extended back of the piers sufficiently far to fence off a yard into which the counterweight descends, to prevent any river-craft from getting in under the descending counterweight.

Mr. Easby.—Do you get equal moments on both sides of the trunnion for all positions of the bridge from dead load?

Mr. Quimby.—Yes; the center of gravity of the whole rotating mass—trusses, floor, and counterweight—is in the trunnion, a little below the center of it. Of course, you cannot counterweight against wind nor against live load. The machinery must hold the leaf against the wind, which may act in either direction. We have figured on a wind pressure of 16 pounds per square foot on the exposed surface of the flooring when the bridge is up, and designed all the machinery for the resulting forces, which amount to 90 tons on the rack of one leaf—45 tons per truss heel.

W. H. Ford.—How far does it project over the channel line?

Mr. Quimby.—When the leaf is fully raised, we have a full way clearance of 200 feet to a point 135 feet above the high-water line. Above that the floor of the bridge extends at an angle of 11° for perhaps two panels—the projection over the clearance line of the fender will be over two feet.

Mr. Ford.—Do you not consider it a serious objection to have that interlocking device at the middle of the two leaves, on account of it being successfully operated only when the operator acts carefully? Is there no danger of smashing something up there?

Mr. Quimby.—There is slight danger of smashing anything. If he puts his leaf down too far, he simply has to raise it again to connect.

Mr. Ford.—If he does not do it right, he is liable to get in trouble; can he not jam?

Mr. Quimby.—No, he cannot jam in the sense of wedging in tight, but within a small range—about eight inches—he can strike and bruise the truss ends.

Mr. Nichols.—Where does the man stand who operates those leaves?

Mr. Quimby.—In the bay-window of either one of the two operating cabins or houses where the controllers are placed. He can operate both leaves from either side of the river. Each operating cabin has two controllers—one controller for each leaf.

J. C. Trautwine, Jr.—How is the control carried across the river?

Mr. Quimby.—By submarine cable, with power from the P. R. T. Co.

Mr. Trautwine.—What time is required for raising one of those leaves?

Mr. Quimby.—About three-quarters of a minute. The total weight moved with each leaf is about 800 tons, and it uses 25 or 30 horsepower.

Mr. Easby.—What kind of paint are you going to use to protect that framing?

Mr. Quimby.—The priming coat is red lead, and the finishing two coats are of white lead tinted different shades.

Paper No. 1104.

THE SANITARY PROBLEMS OF THE CATSKILL AQUEDUCT.

DR. DAVID S. FLYNN.

(Visitor.)

Read September 16, 1911.

The engineering features of the Catskill aqueduct consist of the erection of a large dam for impounding the water-supply, the construction of about 90 miles of aqueduct, a large distributing or equalizing reservoir on high land in Westchester County, New York, and another equalizing reservoir at the beginning of the main distribution system, which runs beneath the city's streets. Contracts for all this work are under way, numbering about thirty, with about ninety camps and employing about twenty thousand men.

The work is under the charge of Mr. J. Waldo Smith as chief engineer of the Board of Water-supply. The consulting sanitary experts of the Board are Mr. A. J. Provost, Jr., C. E., and Dr. Herbert D. Pease, who assigned the author to supervise the field conditions.

The principal sanitary problems relate to housing the workmen and regulating their modes of living by precautions not heretofore fully observed on similar works. Only a very small percentage of the workmen come from the territory through which the work passes, and most of them are foreigners, such as Italians, Slavs, and Poles. There are also a considerable number of negroes, especially on the tunnel jobs.

Laborers of these classes are invariably careless in their habits, settling down in contentment in dirty shacks of their own construction, denying themselves regular and proper nourishment, and oftentimes introducing dangerous conditions to an established community.

With the beginning of the Catskill aqueduct, it became evident that a comprehensive sanitary regulation of the camps and of the men was necessary.

In the first place, the communities through which the work passed should be protected against communicable diseases.

Second, all public and private drinking-water supplies, whose watersheds came within the sphere of action of the aqueduct work, must be protected against pollution.

Third, the health of the workmen must be guarded and every attempt be made to stamp out preventable diseases.

At first an attempt was made to work along the lines laid down by military men in laying out camps and in handling their men, but it was soon found that their experiences were not of much avail here, largely because of the great difference between disciplined men and men of inferior intelligence, such as are generally found among common laborers. Again, local conditions varied and scientific theories had to be bent, warped, and twisted to suit. The following general suggestions as to sanitary regulations have been worked out.

The site must be on dry and properly drained soil, substantially free from trees and remote from ponds, pools, swamps, or other collections of water capable of propagating malarial mosquitos. If the anopheles mosquito has such a breeding-place, the working force may get fever-shaken, and the Italians may transmit to the neighboring communities the more severe forms of malarial infection to which they are subject.

Water-supply.—The invariable result of placing a body of men in camp for an extended stay has been typhoid fever or dysentery. Every army of the world has a greater death-roll from camp diseases than from the wounds of battle. On the aqueduct the typhoid rate for over thirty months has been very low, and this is partly owing to the care which has been exercised in having an abundant supply of good water in each camp. Driven wells have been preferred, protected from surface wash and waste, cased with iron tubing and sealed where driven in rock. Dug wells almost invariably furnish supplies, but if they must be used, they should have a tight platform, preferably of concrete, with a hand- or force-pump, and the walls should be made impervious to ground- or surface-water for a distance of several feet from the top.

The Italian laborer will always seek a natural spring, if such a source is near his working-place, in preference to any other supply, under the belief that only such water is pure. But the pristine purity of a spring is soon lost when a construction gang settles near it. Nuisances are committed in its shed, soiled clothes and tired feet are washed in its cool waters, and the dirty dipper and bucket leave their share of contamination. Diversion ditches should surround springs to carry away surface wash; they should be encircled by and covered with a tight, impervious wall, preferably of concrete, and a hand-pump or overflow pipe should be provided, to obviate the necessity

of dipping. Ponds, lakes, brooks, and rivers are so subject to contamination that their use can be permitted only when the water is effectively filtered.

Above all things, one supply should be chosen and all others forbidden, and periodic examinations of the supply should be made.

Food-supplies.—The first concern is the milk-supply. In the small camps oftentimes no fresh milk is used. But in the larger camps, where there are children and families, it has been found necessary to supervise the farms from which the milk comes, and to advise as to the care of the milk during transportation and delivery to the consumer. The opportunities of contaminating milk with pathogenic bacteria are many. The pail in which it is collected, the person of the milker, the water in which it is cooled, or the water which is added to swell the quantities, are but a few of the common sources by which milk becomes polluted. Where the enforcing of regulations failed and tests showed that milk was not as good as it should have been, pasteurized milk was recommended, and in the one camp where a fair test was made there were no deaths from summer complaints, when during the previous summer there had been ten deaths.

The source of green vegetables, which may be fertilized with human excreta or grown in contact with sewage or polluted water, had to be examined as far as possible, and positive rules made that vegetables be screened when exposed for sale.

Some of the camps have bakeries for supplying the peculiar Italian bread, and these are generally kept scrupulously clean, but here again screening is necessary.

Whatever work is done along these lines is impossible without the coöperation of the contractor, and it is a pleasure to testify that the contractors on the aqueduct assisted in every way to protect food-supplies.

Waste Disposal.—This includes refuse of animal and vegetable origin, which may serve as breeding-spots for flies, and also may contain pathogenic organisms dangerous to the camps when transferred to human hosts by flies; also house dust and rubbish, which may contain particularly the contagion of tuberculosis, diphtheria, and pneumonia.

The waste products may be classified as follows:

1. Human excreta and urine.
2. Surgical and medical dressings, bandages, discharges, etc.
3. Stable manure.

4. Garbage.
5. Slop-water, drainage from kitchens, laundries, wash-houses, etc.
6. Dust and rubbish.

With the exception of No. 5, the only complete and satisfactory way of disposing of such wastes is by incineration.

In the case of human discharges, the history of every temporary encampment of troops and the record of too many sewerage systems have proved that a new method of handling these problems was necessary. The true heroes of the military life, under former conditions, were not the men who lived to fight the battle, but rather those who had to brave the perils of fever and pestilence, ever present in the camp. Ten years ago the facts were laid bare in this country, when, as an aftermath of the Spanish War, typhoid claimed its dead in the camps. The reports showed that more than 90 per cent. of the volunteer regiments developed typhoid fever within eight weeks after going into camp; that about one-fifth of the soldiers of the national encampments had typhoid fever; and that the mortality from this disease amounted to 86¼ per cent. of all fatalities. The records of the British in South Africa, and of the Russians and Japanese in Manchuria, were almost as bad, and only the other day a war scare was started in Germany because a body of troops had been ordered back to their home barracks. The Government denied that it was an act of mobilization and explained it by saying that a number of cases of typhoid had broken out among the men in the manœuvre camp.

The United States army first tried incineration of fecal wastes in 1907, and one of the first conclusive tests took place in Texas. Two battalions of regulars had adjoining camps. In one, pit privies were used; and in the other, the wastes were collected in cans and burned. In the first camp cases of typhoid appeared within a few weeks, and others came until the battalion returned to its permanent post. In the other camp no cases of typhoid appeared during the stay of the troops, and there were no cases immediately after the battalion returned to its post. As a result of such experiences, incineration is now the rule in all movable camps of the army, and it has been adopted by numerous State militia.

The army incinerators are evaporating furnaces. They are designed for easy transport and generally are made of sheet-iron. They possess certain disadvantages for use in construction camps, and consequently, on the aqueduct line, galvanized iron pans, fitting

closely under the seats and easily removable through a hinged door in the back of the closet, in conjunction with masonry grate bar furnaces, have been found cheaper and more satisfactory. The general practice now is to build the furnace in two or three sections, and in it dispose of all the refuse of the camp.

In twenty-nine months of supervision of the Catskill aqueduct there were but fourteen cases of typhoid fever, and this very low number is owing to the very general practice of incinerating human wastes, the rubbish and garbage, stable manure, in many camps, and to general screening.

The method adopted to dispose of *liquid wastes*, such as kitchen slops and the waste from laundries and wash-houses, is that of collection by drains, which lead through a grease trap into a settling basin and duplicate sand filters. The effluent then may be delivered to any stream not used as a potable supply. Should it be used as a drinking supply, further treatment is used, generally that of dosing with hyperchlorite of calcium, by means of an automatic apparatus.

Ventilation, Heating, and Lighting.—Human beings, after all, are machines, and, like them, will not reach their highest point of efficiency unless certain precautions are taken in regard to their repair and upkeep. The upkeep of the human body requires a definite amount of breathing space, a fixed supply of fresh air, added at a regular rate, a certain amount of direct solar light, and adequate means of artificial heating and lighting.

The minimum air-space per occupant was fixed at 400 cubic feet, and it was specified that some method of ventilation should be supplied besides that given by doors and windows. It is generally accomplished by louvers on the ridge of the shacks. This ventilator has a free horizontal area of about ¼ foot per occupant. The minimum of window-space was set at 3 square feet per occupant, and these windows must be placed on all sides of the buildings.

Medical Supervision.—The Board of Water-supply contracts all specify that one or more qualified medical practitioners shall be employed, and on all the watersheds the board pays the contractor to build a man-proof fence, which will keep the men in certain bounds and which tends to keep down promiscuous committing of nuisances. The important step that has been taken forward, on the Catskill aqueduct, is the recognition of preventive medicine. Contractors' physicians have as a duty the examination of every applicant for work, so that men suffering from evident disease may be at once rejected. Next the laborer is vaccinated and given a certificate,

without which he is not permitted to work. The following is cited as an example of the value of preliminary examination to the contractor. On one of the contracts the managing engineer was not in favor of it, as he claimed that he would have to permit the foremen at each shaft to take any man they could get to fill out a short-handed shift. Within a week two muckers were taken from that tunnel suffering from pulmonary hemorrhages, and removed to the company hospital. One had worked for three hours, and died in the hospital at the end of nine days. The other had worked for five hours and died after an illness which required constant nursing for twenty-nine days. As eight hours' mucking would not balance thirty-eight days of hospital expenses, the system of preliminary examinations was thereafter made the rule of this job. Furthermore, within the next month the doctor here rejected eight applicants for work who were suffering from acute tuberculosis.

Hospitals.—Each contract must have a building, to be used solely as a treatment hospital, to be erected on a site and in accordance with plans approved by the sanitary experts. These buildings must have a doctor's office and dispensary, an operating room, a ward with beds for 2 per cent. of the working force, allowing 600 cubic feet for each occupant, an isolation room with two beds, nurses' room, bath-room, linen closet, and storage for extra cots, etc. Running water must be furnished to the doctor's office and bath. The buildings must be heated and lighted.

Isolation Hospital.—Each contractor must also set aside a small building for this purpose, to be used as a pest house. It is placed at a distance from other habitations. Many of them are surrounded by a man-proof fence, and they can be patrolled night and day by the aqueduct police. The simplest form of building consists of a ward, an attendants' room, and a kitchen.

The contractor's physician is held responsible for the general condition of his camp and has to make regular inspection trips. He then forwards weekly to the office of the consulting sanitary experts, on a prescribed form, a report covering camp population, total number of employees, vaccinations, surgical cases, medical cases, deaths, transfers, sanitary conditions of camps and works, etc. On the watersheds he is also required to supply every week the name of each man living outside of the camp. Cases of contagious and infectious diseases are reported by telephone or telegraph immediately after tentative diagnosis, using a prescribed code.

Supplies of vaccine, diphtheria and tetanus antitoxins, and anti-streptococcic serum, the Pasteur treatment, and typhoid vaccine are furnished to the contractor free of charge by the Department of Health of New York city. In suspected cases of tuberculosis, diphtheria, typhoid, dysentery, etc., samples of sputum, membrane, blood, or feces, as the case may be, are forwarded for laboratory examination, and reports wired to aid the physicians in making certain diagnoses.

With about four thousand men working for over two years within the confines of the Croton watershed, there has been but one case of typhoid. This case was positively recognized by the Widal reaction within three hours, and the patient was moved to a hospital outside the watershed within twenty hours after the blood was drawn by the physician.

Ten important watersheds are touched on by the aqueduct, but by far the most important of these is the Croton shed, from which New York's present supply comes. This shed is occupied by about 10 miles of the line of work, and contains five camps. The camp sites have been leased or purchased by the contractors after most careful consideration was given as to their suitability. Direct compensation is given by the city, under the contracts, for installation and maintenance of the camps, and practically all the working force is obliged to live in the camps. The exceptions from this rule are a few of the skilled laborers owning their own homes, the location of which is shown on an official plan, and the sanitary condition of which must be reported weekly by the contractor's physician. Nothing but incinerating closets have been permitted, and the camp garbage and rubbish is likewise burned. Each room has to be swept daily by its occupant, and the sweepings are gathered from the hallway by a sanitary gang, by which the collections are carried to the incinerating furnace. Each contract has a physician who must stay within a mile of the camp at all times, and is held personally responsible for the sanitary condition of the contract. The camp is surrounded by a man-proof fence and must be illuminated with electric lights from sunset to sunrise.

Surrounding each camp and just outside of the man-proof fence are collecting ditches for conveying all rain-water and surface wash to the sanitary works. These ditches are sufficient to care for a run-off of 4¾ inches in one hour. Sedimentation and storage basins have capacity for run-off, in excess of filtration rate, amounting from 60 to 80 per cent. of Talbot's curve for twenty-four hours.

Filters have 3 feet of selected sand; effective size, 0.25 to 0.35 mm. The estimated rate of filtration is 2½ million gallons per acre per day, without negative head.

Sterilizing apparatus is of the automatic type for treating filtrate with hypochlorite of calcium, 30 per cent. available chlorin, at rate of 25 pounds bleach per million gallons.

Retention basins have a capacity for fifteen minutes' retention at maximum rate of run-off.

There are no flush closets in any of the watershed camps. Liquid wastes, other than urine, flow through sinks into a drain, which leads to a grease trap with capacity for about four hours' flow from maximum population, on a basis of 40 gallons per capita daily. The effluent from this trap is discharged upon the surface of one of the filter-beds, which is trenched for this purpose and provided with a diverting gate to control the flow. The filtrate then passes through the sterilizing apparatus into the retention basin before reaching a water-course. Incinerating closets are placed in the camp, at shafts and portals and along the line of work, and tunnels are provided with removable water-tight receptacles, the contents of which are brought to the surface and burned daily.

Contractors and engineers should give greater attention to the sanitation of labor camps. The efficiency of the working force is increased in direct ratio to the improvements made in its living conditions.

If figures ever can be relied on, the Board's statistics as to health would prove that sickness is diminished in the well-kept camps. From observation the author knows that some of the contractors have laborers who have been with them for a number of years, and these men have always been found to be the ones who had clean shacks, and oftentimes a garden outside. It is this class of men which forms the first-class organization, and it is believed that this class of faithful, competent, and trained laborers would be formed in large numbers were camps made according to the lines set forth in this paper.

DISCUSSION.

Henry Leffman.—The remark just made is obviously in accord with the thoughts of all of us. The paper is progressive, and takes a position with which every intelligent person must agree. It is valuable in bringing to our notice in detail the successful accomplishments of sanitation in accordance with up-to-date standards. There has been a struggle against these methods, and we are just beginning to realize the full effects of men working in masses, and can only

conclude that there must be an artificial system of sanitation in which the rights of the individual must give way to the rights of the community, and a restriction be put upon what might be called "spontaneous behavior."

I have been interested all my life in questions of sanitary engineering, beginning forty years ago to study the subjects of water-supply and sewage-disposal, and I have to some extent a knowledge of how this work has grown and how difficult it has been to make progress. Forty years ago it was difficult to convince anybody engaged in engineering or in public affairs of the necessity of strict methods. I can recollect when even stables were supposed to be "healthy," and I know that the getting rid of such ideas has been a very slow growth. It has been necessary, as the writer of the paper said, to use the argument of profit as well as the argument of decency in enforcing the rules which have been laid down for the safeguarding of health and the elimination of disease-fostering sources. We have yet to show people that it will pay to do right. Such demonstrations as these will go far toward holding up the hands of those who are in charge of these works and urging still more radical reforms.

With regard to typhoid fever, it is now thought that a great deal of it is due to distribution by contagion, and not only to drinking-water. In spite of all precautions typhoid may be introduced by some one infected with the disease, and one might think the precautions taken are unnecessary; but the low figures do not, under these conditions, need any further demonstration of their value.

Now, it may perhaps seem a little like levity to say so, but I could not help wondering, when the "man-proof fence" was mentioned, whether a "woman-proof fence" had been considered also. How about prostitution? It will be more difficult to control that, perhaps, than any other cause of disease; but it will come up. As other conditions are rendered less important by the elimination of their results, the question of venereal disease will come to the fore.

We owe a vote of thanks to the author of the paper; it illustrates practical conditions and is a very important step in civil engineering operations.

H. C. Berry.—I would like to ask about the typhoid vaccine given to the soldiers the other day for typhoid fever?

Dr. Leffmann.—The treatment of typhoid by toxins is new, and I do not think we yet have data sufficient to give a positive opinion as to their value, but it is possible in certain cases, where they are taken in time, to arrest the disease. For instance, if one can get the ordinary vaccination started so that it will be well on its way before the symptoms of smallpox appear, the vaccination will modify the smallpox. Unfortunately, these diseases have different periods of incubation, and it is some time before people really know what is the matter with them, although they may have been ailing for some time previously. Every now and then occur cases of "walking typhoid."

Mr. Robert Schmitz.—I think the work done on this aqueduct as described by Dr. Flynn is highly commendable, and is a long step in the right direction, and shows improvement in the methods of doing such work. I trust these methods will be followed voluntarily at other large works, and I hope that in time these methods, or similar methods, or perhaps even improved ones, will be prescribed by law.

IN MEMORIAM.*

JAMES CHRISTIE.

Died August 24, 1911.

By the death of James Christie the engineering profession has lost one of its most active and intelligent workers. To us, of The Engineers' Club, the loss will be much more than that of a co-worker and zealous fellow-member; we shall miss the versatile mind, the companionable temperament, the genial wit and humor, and the wealth of experience in many phases of life, that rendered him so prominent and so much esteemed in our social circle.

James Christie was born August 28, 1840, near Ottawa, Canada. He was of Scotch descent. In default of college training, he supplemented his early training in the public schools of his native place by wide reading and close study of the questions that came before him, and by a knowledge of French, which widened his opportunities for study.

When about eighteen years of age he began as an apprentice in mechanical engineering in Detroit, serving as machinist and draftsman. Just before the beginning of the civil war he was for a short time employed in railroad work in southwestern Missouri, and he then entered the service of the I. P. Morris Company, proprietors of the still famous Port Richmond Iron Works. Here he remained about four years, being associated with such veterans as John Hartman and Washington Jones. His stay at Port Richmond was interrupted for a brief period by service in the U. S. army in 1863.

About 1865 he was for a short time in business with Henry Lewis Butler, under the firm name of Butler and Christie.

Mr. Christie's most important service to engineering, in both its theory and its practice, began in 1876, when he entered the employ of the Iron Works at Pencoyd, Pa., which then was a relatively small establishment. Mr. Christie was general mechanical assistant, and, to a great extent, his own draftsman. He began at once to improve the methods of work, applying means that would now be termed "scientific management," seeking and eliminating sources of waste,

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* Prepared by Henry Leffmann and John C. Trautwine, Jr.

introducing more efficient machinery, and organizing and regulating labor. By these means he enabled Pencoyd to meet the competition of Pittsburg, and made it one of the largest and most efficient works in the eastern section of the country. The owners, A. and P. Roberts & Co., entered heartily into the spirit of Mr. Christie's efforts, and called to his aid experts in the several new departments established. By his wide knowledge of mechanical engineering, universally recognized integrity, and engaging personality, Mr. Christie secured and held the respect and co-operation of these special assistants.

During all these years he took an active part in the promotion of engineering science, in public affairs, and in questions of social reform. The catholicity of his literary tastes carried him beyond the narrow limits that so often restrict the expert, and to this fact is largely due the charm that his friends and acquaintances found in his companionship.

In 1884 he published "Experiments on the Strength of Wrought Iron Struts," based on tests made by him at Pencoyd. This paper, one of the classics of the profession, won for him the Norman medal of the American Society of Civil Engineers.

His interest in public affairs led to his being occasionally chosen for public office on some of those rare occasions when an American community, having wearied of corruption, seeks an honest man. About 1870 Mr. Christie was Mayor of Phillipsburg, N. J., and from 1907 to 1910 was Select Councilman from the 21st ward of Philadelphia, being one of the few members of that body chosen on an outspoken reform platform. In this ward, of which he was a resident for many years, he took active part in local educational movements and was also interested in material development, being a director in the local trolley line.

While at Phillipsburg, Mr. Christie was superintendent of the Phillipsburg Manufacturing Co., builders of iron bridges, serving with Mr. Alfred P. Boller, chief engineer. Here he and Mr. Boller made important studies of the design of rolled beams, in which work they were assisted by Professor W. H. Burr. Recently, Mr. Christie built, at Ambridge, Pa., the works of the American Bridge Company, the greatest bridge plant in the world.

Mr. Christie made numerous contributions to general and scientific literature. In Philadelphia his activity in scientific work was principally in association with The Engineers' Club and the Franklin Institute. For many years he was a member of the Board of Man-

agers of the latter institution, and for a short time, secretary. He was elected a member of The Engineers' Club in 1884, and president in 1892. He was one of two members who have had the honor of a second election as president, but it was not his lot to complete his second term. At the time of his death he was a member of the American Philosophical Society, Fellow of the American Association for the Advancement of Science, member of the American Society of Civil Engineers, of the American Society of Mechanical Engineers, and of the Grand Army of the Republic. He was twice married. In 1866 he married Jane Maxwell. Three of their five children are now living. Recently he married Elizabeth Janney, who, with an infant son, survives him.

To the members of The Engineers' Club it will not be necessary to enumerate the services, direct and indirect, that Mr. Christie has rendered the Club, or to set forth in detail the large part he took in developing the spirit of good-fellowship so necessary to an organization intended to combine social opportunities with professional advancement. During the more than a quarter-century of his membership he was an almost constant attendant at the meetings, and rarely failed to give illuminating aid in the discussion of the subjects brought before the Club. His high sense and appreciation of humor enabled him to give agreeable relief to the scientific discussions, but his excellent judgment, self-control, and sincere interest in all that makes for scientific progress and for social uplift gave unostentatious dignity to all his utterances.

His successful career is a striking instance of what can be accomplished by persistent devotion to the problem in hand, even without the so-called "educational advantages" now-a-days regarded as a necessary preparation for a professional career.

By his death engineering science has lost one of its most faithful and efficient students and workers, the community a useful and upright citizen, his friends and acquaintances a revered companion, his family a loving and loved husband and father, and The Engineers' Club of Philadelphia one of its most esteemed members.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Adjourned Meeting, July 20, 1911.—Present: President Christie, Vice-Presidents Hewitt and Plack, Directors Swaab, Halstead, Develin, Gilpin, and Vogleson, the Secretary, and the Treasurer.

The Secretary presented a report of the financial condition of the Club, which showed a net gain of $626.44 for the first half of the year.

Upon motion of the Secretary the sum of $105.95 was appropriated to the Entertainment Committee to cover deficits in the entertainments during the past season.

A list of members delinquent in dues and house charges was read, and it was ordered that these delinquents be carried upon the roll until the regular meeting of the Board in September, at which time the Treasurer was instructed to report upon each individual case.

The following resignations were read and accepted: I. W. Hubbard, John E. Allen, Chas. S. Redding, J. L. Beaver, B. G. Love, W. D. Gernet, M. R. Pugh, H. R. Goshorn, H. L. Benner, E. B. Smith, R. E. B. Sharp, and Thos. A. Edison.

The Secretary announced the deaths of Mr. Francis Schumann and Mr. Howard Wood.

Upon motion, Mr. C. H. Ott was reinstated to active membership.

It was ordered that the Engineers' Club apply for associate membership in the National Fire Protection Association, and five dollars was appropriated to meet the payment of dues of this organization.

Special Meeting, August 28, 1911.—Present: Vice-Presidents Hess, Hewitt, and Plack, Directors Medus, Kerrick, Worley, Cooke, and Gilpin, and the Secretary. This meeting was called on account of the sudden death of President Christie, on August 24th. Vice-President Charles Hewitt was appointed to represent the Club at Mr. Christie's funeral.

Messrs. Henry Leffmann, John C. Trautwine, Jr., and Wm. R. Webster were appointed a committee to prepare a memorial, and the Secretary was instructed to prepare resolutions to present at the next regular meeting of the Board.

The next regular Board meeting was, upon motion, advanced from the 14th to the 5th of September.

Regular Meeting, September 5, 1911.—Present: Vice-Presidents Hess and Plack, Directors Hutchinson, Swaab, Halstead, Develin, and Vogleson, and the Secretary.

The matter of the execution of a memorial or resolution of the late President, James Christie, was discussed, and ordered laid over until the following meeting of the Board.

The committee on the regulation of smoking in the meeting-room stated that it would make a report at the next meeting of the Board.

The Treasurer, who was to report at this meeting on the delinquent accounts,

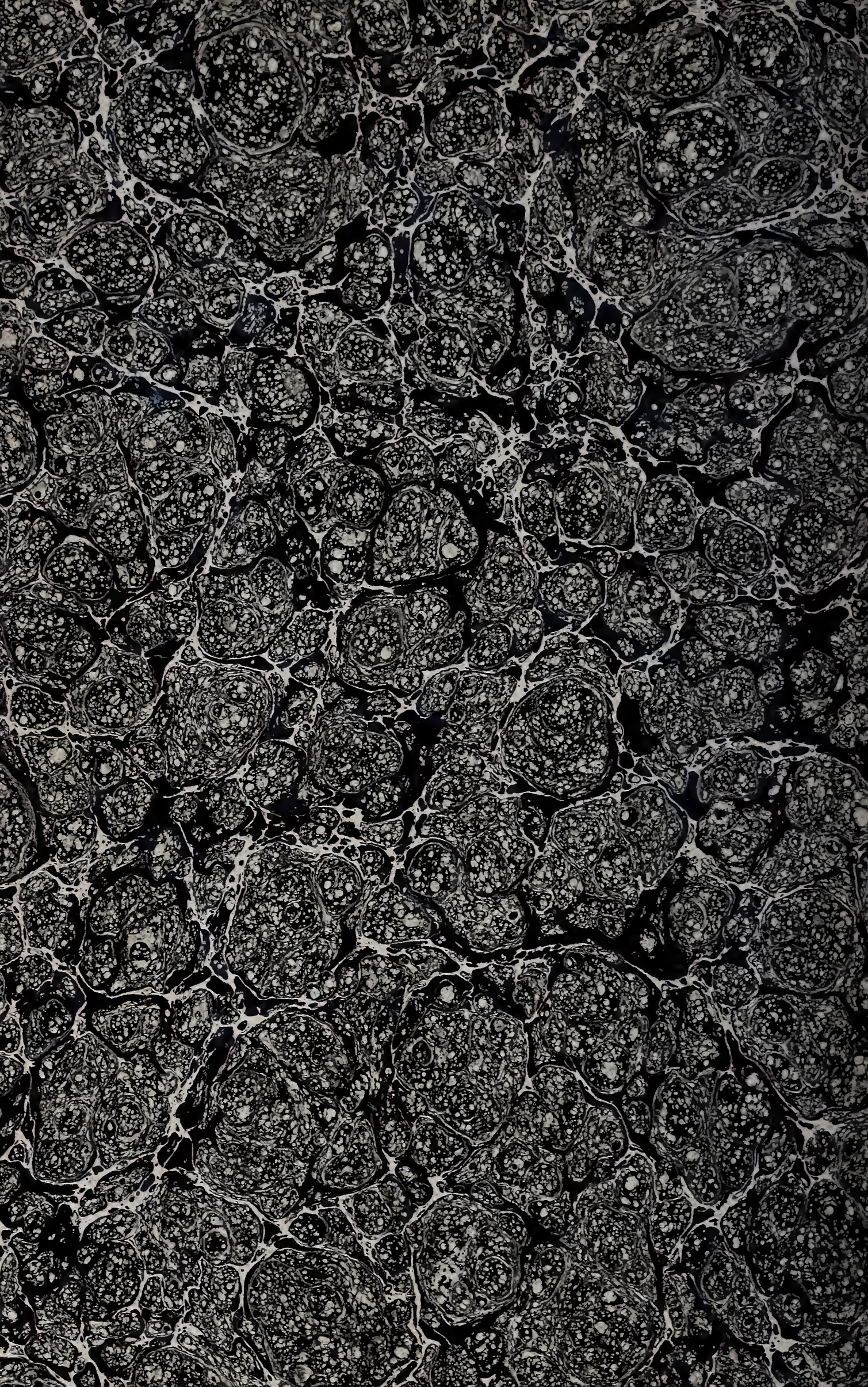
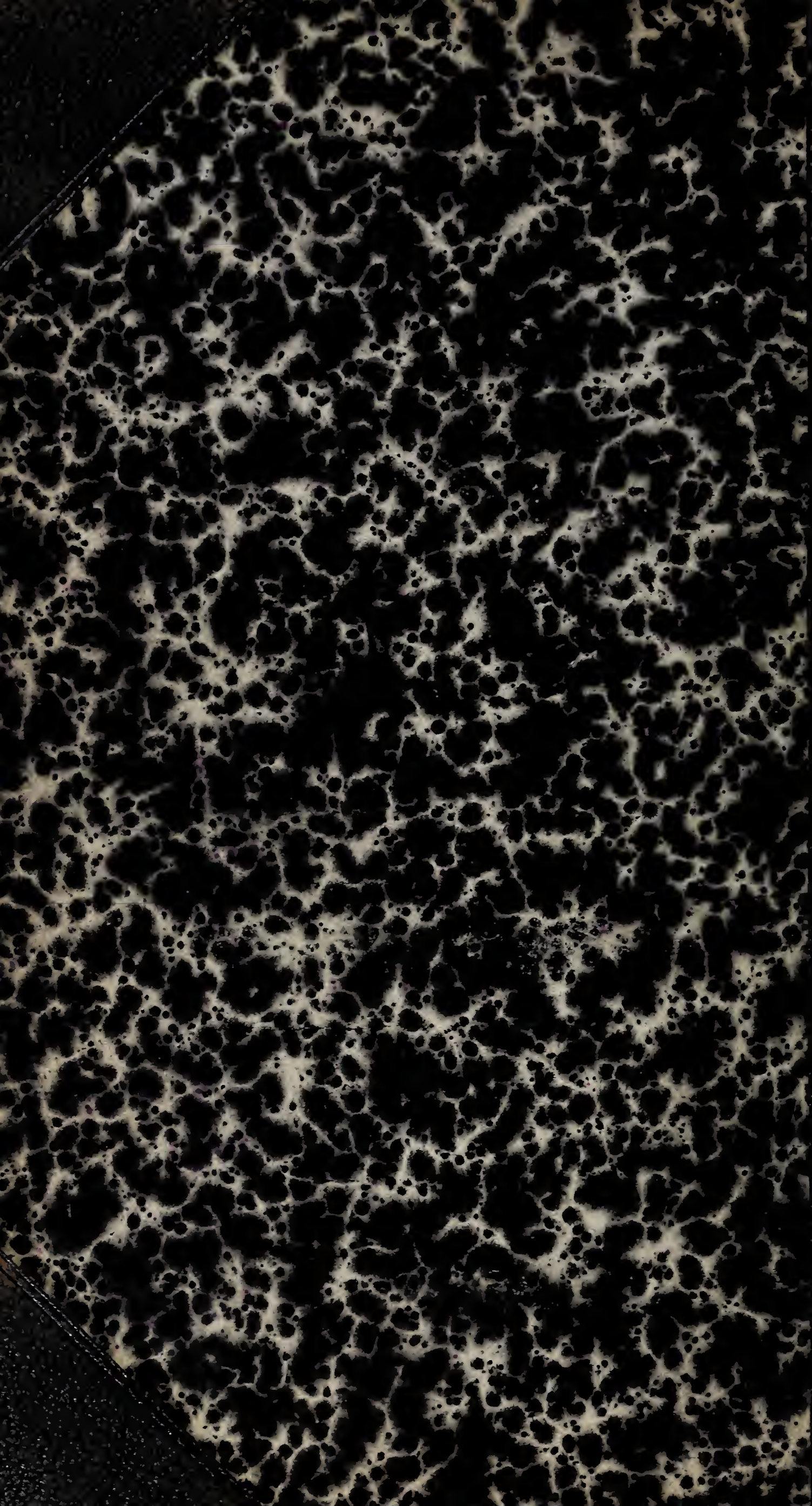
wrote, stating that he would be unable to attend this meeting, and would report at the meeting following.

The resignation of Mr. S. J. Dickey was read and accepted as of July 1, 1911.

Correspondence from Mr. Carl Hering, relative to certain matters in the house, was tabled until the next meeting of the Board, so that the chairman of the House Committee could be present during the discussion.

A letter from the Third Conservation Congress, requesting the appointment of delegates, was ordered to be read at the following regular meeting of the Club.

The work of the Committee on Standards was discussed, but no formal action was taken.

Mr. Henry Hess was elected President of the Club to fill the vacancy caused by the death of Mr. Christie. Mr. Edward S. Hutchinson was elected first Vice-President in Mr. Hess's place, and Mr. Benjamin A. Haldeman was elected Director in Mr. Hutchinson's place, all elections to take effect immediately, and for terms to expire in February, 1912.

It was ordered that the regular meetings of the Board for the coming winter be held on the third Wednesday of each month.